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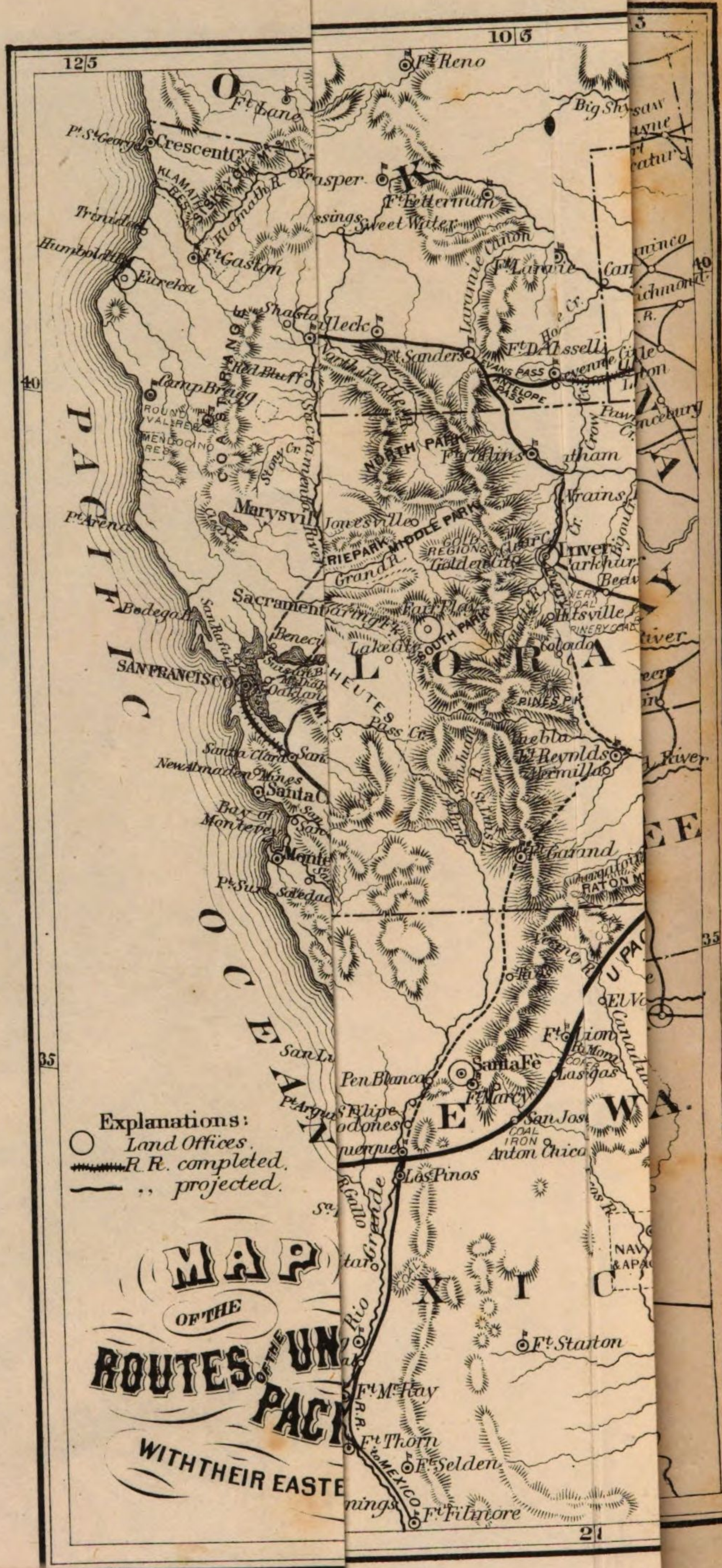
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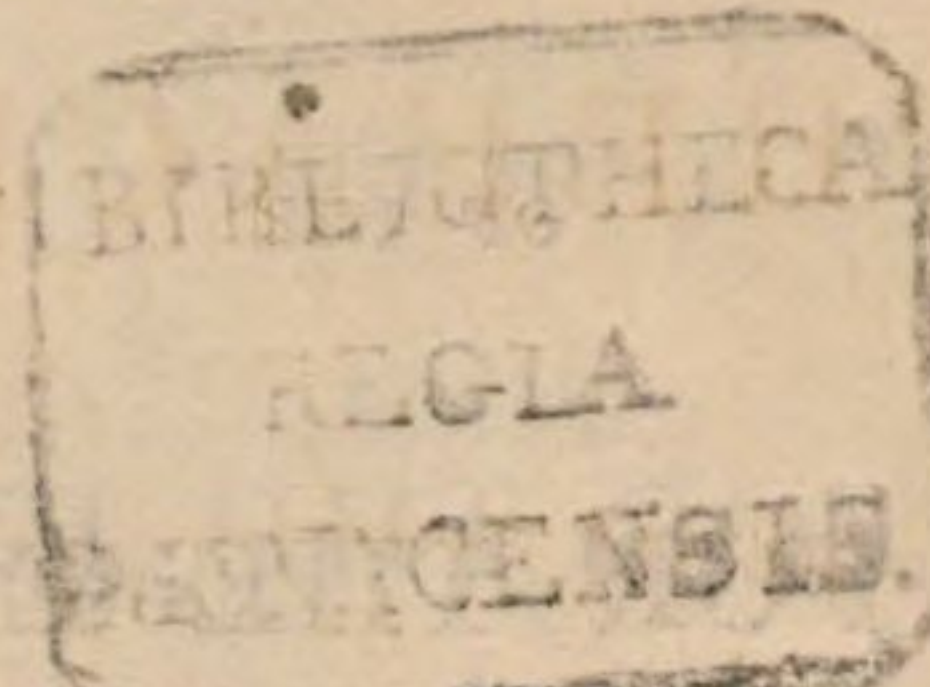
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NOTES
ON THE
GEOLOGY
OF THE
SURVEY FOR THE EXTENSION
OF THE
UNION PACIFIC RAILWAY, E. D.,
FROM THE
SMOKY HILL RIVER, KANSAS,
TO THE
RIO GRANDE.

By JOHN L. LECONTE, M. D.

PHILADELPHIA:
FEBRUARY, 1868.



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PREFACE.

THE material for the present report was obtained by me during the summer and autumn of the year 1867, while connected with the survey of the Union Pacific Railway, Eastern Division, under General W. W. Wright, Chief Engineer of the Company.

The lines determined by actual measurement commenced at Fort Wallace, on the Smoky Hill river; at Fort Lyon, on the Arkansas, the party was divided; one division under Mr. J. Imbrie Miller was sent up the Arkansas and Huerfano rivers through Sangre de Cristo pass to the valley of the Rio Grande. The main body, consisting of two divisions, proceeded up the valley of the Purgatoire, crossing the Raton by Trenchera pass, and thence to Fort Union, from which place a party under Mr. Eicholtz was detached to survey the eastern extremity of the Raton mountain.

During the progress of the survey from Trenchera pass to Fort Union I was occupied in examining the coal in the neighborhood of the Raton.

At Vegas the party was again divided; the portion under charge of Mr. Eicholtz surveying a line from the Lagunas Coloradas, near the head of the Cañon Blanco through Abó pass to the Rio Grande; the other division accom-

panied by General Wright proceeding along the route indicated in my report to the same Lagunas, thence via Cañon Carnuel to the Rio Grande below Albuquerque.

The survey was then continued down the west bank of the Rio Grande to Fort Craig, New Mexico, all three parties uniting there on the 1st of October.

My assistant, Dr. C. C. Parry, accompanied the party of Mr. Miller. I have not received his report, but although it may be expected to give much information regarding the geology of the line surveyed, it can have but little practical bearing upon the railroad enterprise, since the route, as was anticipated by General Wright, proved impracticable.

The region south of the Raton, traversed by the main party, and subsequently by the division of Mr. Eicholtz, is simply a surface of cretaceous strata, broken through at points by volcanic eruptions manifesting themselves partly as cones with craters at the summit, partly as lava streams which form table lands or mesas capped with basalt.

Of the geology of the country surveyed by Mr. Eicholtz, from the Lagunas Coloradas through Abó pass, nothing is known to me. No specimens were collected and no observations made on the nature of the rocks. I merely saw, from the west side of the Rio Grande, at a great distance, that the structure of the Manzana mountain, through which the Abó pass is a gap, is the same as the Zandia, of which it is the southern continuation.

In a great continental railway, which is of national importance, and which must be aided, at least temporarily, by the national treasury, the interests involved naturally group themselves in proportion to their importance, as follows: 1. Fuel. 2. Materials for construction and repair. 3. Local resources for the support of the road when built.

I am glad to be able to report that in these three essentials, the line surveyed from Fort Lyon to Fort Craig affords abundant inducements to enable the road not only to be built, but to be remunerative, when constructed.

The report is divided into three parts; the first contains the record of observations made during the survey; the second, the deductions therefrom, regarding the resources of the region traversed; the third, conclusions concerning the geological structure and method of development of that portion of the continent.

This arrangement has been adopted in order that any errors of observations, (and who could escape such on a survey conducted with rapidity unprecedented in the annals of civil engineering, through a country in great part uninhabited,) may be more readily corrected by those that follow me, with opportunities for more detailed investigation.

In conclusion, I desire to express my sincere thanks to Mr. Leo Lesquereux and to Dr. F. A. Genth for the valuable assistance, rendered gratuitously, for the interest of science, in determining the fossil plants, and the metamorphic and eruptive rocks which were collected.*

* It was my intention to append to this report a list of the geological and mineralogical specimens obtained, but believing that this is unimportant in reference to the practical object sought by the company, and that science will be better served by the results being published in another form at a later time, I have, after reflection, thought it unnecessary to increase the size of the pamphlet by such an addition.

PART I.

DESCRIPTION OF THE COUNTRY.

§ 1. SALINA TO FORT WALLACE.

My reconnoissance commences with the starting of the expedition from Salina, Kansas, on Saturday, June 7, 1867. Our course lay in the alluvial plain of the Smoky, here very broad, and already partly under cultivation and yielding abundant crops. The valley gradually becomes narrower, and is flanked each side by hills of coarse brown sandstone, containing irregular concretions of oxide of iron; near the crossing of Spring creek, about a quarter of a mile south of the road, this rock abounds in fossils. The few fragments for which I could give room, have furnished to Mr. Conrad no less than fourteen species, all of which seem to be new. The genera to which they belong are as follows: *Nucularia*, 2 sp., *Crassitella*, 2 sp., *Avicula*, 2 sp., *Protocardia*, *Venilia*, *Tellina*, *Cerithium*, *Ostrea*, *Natica*, of each one species, and one new genus, not yet investigated: these strata therefore belong to our lowest cretaceous, or Dakota group of Messrs. Meek and Hayden, thus establishing the existence of that formation at a more eastern point than has been done by previous surveys.*

Similar rocks, not containing fossils, or at least from which no fossils were collected, continue nearly to Fort Harker, where the sandstone becomes less ferruginous, of a reddish and pale yellow color, and contains leaves of trees of exogenous growth. A collec-

* Since my return I have learned from Mr. Meek that Professor Mudge, of the Kansas Geological Survey, has procured specimens from the same locality.

tion obtained in November, 1866, has been examined by Mr. Lesquereux;* others were procured while I was at the post, and have also been submitted to him.

Beyond this the cretaceous sandstone becomes covered with strata of clay and limestone; the latter, at Bunker Hill station, contains a *Belemnite* not described, and *Inoceramus problematicus*, with teeth and vertebræ of a species of shark belonging to the genus *Lamna*. The rock is of firm texture and suited either for building or burning into lime. On the banks of the small stream east of Walker's creek, the strata of slaty clay contain many teeth of fishes and sharks; adjacent to them is a thin bed of *Ostrea congesta*, which is a very important geological horizon for a long distance west of that point. Above the oyster bed, and limiting the tops of the hills, is the *Inoceramus* bed of limestone. On the banks of the Smoky, from near Salina to beyond Walker's creek, exposures of carbonaceous clays, and very impure lignites are frequent, but are worthless. The same strata are sometimes exposed in the ravines, and occasionally contain very perfect crystals of selenite, which have caused them to be noted on some maps as gypsum beds.

The soil is fertile, and covered with a good growth of buffalo grass to beyond Fort Hays, where, from the diminished rainfall, it becomes rapidly more barren. As far as the settlements extend, the buffalo grass is being replaced gradually by species of more vigorous growth, imported chiefly in the excrements of cattle from more eastern regions.

Middle cretaceous strata continued to form the bluffs of the valley of the Smoky, the lower ones gradually disappearing under the upper as we progressed westward. The *Ostrea* bed showed itself in several places, until west of Smoky Hill station it reached the level of the river bed and was lost to view.

The lithological characters of these strata vary greatly at different places. The following notes taken from my diary contain the substance of the limited observations which I was able to make during our journey to Fort Wallace:

June 18. Between Lookout station and White Rocks, saw in ravines and along the banks of the Smoky, dark-colored clays, somewhat carbonaceous in places; *Inoceramus problematicus* also

* Trans. Am. Phil. Soc., xiii, 430.

abundant. Above these dark clays are strata of yellowish and brownish sandy clays; above these, at Stormy Hollow, indurated masses, surrounded with fibrous and crystalized carbonate of lime. Fragments of gigantic *Inocerami* occurred at the same place.

Five miles east of White Rock were seen beds of a pale yellow marl, splitting into rectangular fragments: this is the lower part of the bed, which at White Rock is white and chalky. I dissolved a small quantity in acetic acid, and a residuum of clayey material remained; I propose on a future occasion to have a proper microscopical examination made of these marls. The only fossils found were a small oyster and fragments of gigantic *Inocerami*. Arriving late in the day, and leaving very early next morning, no opportunity was presented for careful search after fossils.

June 19. At Downer's station the same strata were seen as at White Rock, but less pure. The water at Downer's is slightly sulphuretted; a spring of weak sulphur water is known about one mile from the station.

June 20. About midday passed Castle Rock, an isolated mass about one hundred feet high, near a higher bluff, of which it was formerly a part; the latter exhibited in a descending series the following strata:

1. Indurated clays, containing gravel, weathering in such manner as to produce small cavities.
2. Yellow and gray calcareous clays arranged alternately in thin strata.
3. Thick stratum of yellow marl.
4. Thin bed of *Ostrea congesta*.
5. Thick stratum of gray calcareous clay.

A few drift pebbles, chiefly of jasper, were seen on the top of the hill. The soil is very poor and dry; the grass on the hills very short, in the valleys somewhat longer.

June 21. From Grinnell Spring to Carlisle Hall, passing by Chalk Bluffs, at which point the road touches the Smoky, the banks are of gray clay, about thirty feet above the sandy bed of the stream, which is here very small and shallow. The clay banks contain many rounded and flattened nodules of iron pyrites, on the surface of which beautiful crystalline facets are exhibited; these nodules have been mentioned by some travellers as "meteoric iron."

At Carlisle Hall, bluffs of similar strata to those of Castle Rock present the appearance of gigantic ruins. Between the gray clay at the base of these cliffs and the yellow marl is found the thin bed of *Ostrea congesta*. The top layer of these remnants of the former extension of the plateau is the stratum of brown gravelly marl, which is harder than the strata below it, and protects them from erosion.

June 22. Carlisle Hall to beyond Smoky Hill station, passing Monument station, near which are isolated pillars of bluff resembling those at Carlisle Hall and Castle Rock. The *Ostrea congesta* bed here reaches the lower level of the river valley, but the gray stratum below it is still visible in the bluffs south of the river, showing a slight descent towards the north. The bed of marl above the oyster bed is sometimes yellow, sometimes nearly white. Vegetation generally very poor, with good grass only in a few places. *Artemisia* more abundant than yesterday.

June 23. Camped in Death Hollow, near the forks of the Smoky. The bluffs which approached the river at the first crossing, are about thirty feet high, and composed of yellow marl. Vegetation poor, similar to that seen yesterday.

June 24. Arrived at Fort Wallace. The permanent buildings of the post are made of blocks of the yellow marl above mentioned, a quarry of which has been opened in the bluffs south of the Smoky. The stone is very uniform in texture, fine grained, and so soft as to be easily dressed with carpenters' tools. It is said to grow hard; on exposure to the air, since it contains magnesia, it is probable that such is the case. The blocks vary in color from yellow to pale red, and nearly white. The only fossils are vertebræ and scales of true fishes, with an occasional tooth resembling *Enchodus*. The same fossils were collected by Dr. Hayden in the bluffs of the lower part of the Niobrara valley, and they indicate the strata as belonging to No. 3 of the cretaceous series of Meek and Hayden, or the upper middle division of our western cretaceous system.

Fort Wallace is situated on a tongue of the plateau north of the Smoky. On the declivity west of the buildings a well has been dug, in which a good supply of water is obtained at the depth of twenty-nine feet, on a level with the sandy bed of the stream, which is nearly half a mile distant. On the higher plain of the parade ground a well has been sunk eighty-four feet; no

water was found, except a slight leakage at the junction of the surface soil with the yellow marl. Below the yellow marl blue clay was found, but no record of the thickness of the strata was preserved. The top of this well is forty-three feet above the sandy bed of the Smoky, the bottom is consequently forty-one feet below the level of superficial drainage as indicated by that stream.

From the bluffs south of the Smoky a large quantity of clayey limestone has been brought to fill the well. I found in these pieces of rock very good specimens of common opal. They are white and look like porcelain, and were formed by the infiltration of siliceous springs into the cretaceous strata; the magnesia contained in the latter caused the silica to assume the opaline rather than the agate or chalcedonic form.

I received from Dr. Turner, U. S. A., the medical officer of the post, several fine crystals of sulphate of baryta, found in geodes, with calcite and selenite, about seven miles west of the fort. The hostility of the Indians prevented a visit to the locality. Dr. Turner had found in the same ravine with the geodes some irre-cognizable fragments of fossil bone.

I obtained, while at the fort, three imperfect vertebræ of a large reptile, pronounced by Professor E. D. Cope to be of Dinosaurian or Plesiosaurian affinities. Mr. Comstock, the guide and scout attached to the fort, informed me that almost the whole skeleton of this animal is exposed in a ravine fifteen miles northwest of the post.* The ravine debouches into the Smoky by the Henshaw springs, and not far from the skeleton exhibits beds of dark clay containing about three inches of lignite.

In digging a well near Pond Creek station a lower jaw of the recent buffalo was found at the depth of about seventeen feet.

* On the termination of the Indian war, Dr. Turner explored the locality above mentioned, and recovered about 35 feet of the vertebral column, with fragments of the extremities and head of this gigantic reptile: he has liberally presented these valuable specimens to the Academy of Natural Sciences of Philadelphia, and they are now on their way to that institution.

§ 2. FROM WALLACE TO LYON.

On ascending from the Smoky to the plateau southward, the same strata mentioned in the preceding chapter are seen. The rock on the plateau is rarely exposed; where seen it is siliceous, white, opaque, and opaline in texture. The surface of the plateau is nearly level, with a few wide and deep, but not abrupt ravines, destitute of water, except after rains. The bluffs, where the structure is visible, consist of a yellow marl, more arenaceous and slaty than at Fort Wallace; capping this marl, but gradually merging into it, I observed six or eight feet of gray sandstone, and above that a bed of coarse, gravelly conglomerate, containing fragments of gray and yellow marls like those of the Smoky, with quartzose and jasper pebbles of small size. At this exposure the dip was 25° to 30° nearly southeast, but in general the strata are almost horizontal. I found in one of the ravines a red jasper pebble containing imperfect impressions of a species of *Spirifer*, probably brought by drift action from the palæozoic strata of the Rocky mountains.

The vegetation on this elevated plain consists chiefly of scattered tufts of stunted buffalo grass, the earth between them being bare. The soil is very light and pulverulent; a specimen was taken for analysis, but has not yet been examined. In some of the ravines a feeble growth of willow bushes was observed, but on digging, nothing was found except a superficial dribbling of bad-tasted water, strongly impregnated with sulphur and vegetable mould.

About five miles north of the Arkansas I obtained specimens of a white argillaceous magnesian limestone, containing no fossils, but evidently belonging to the same series of cretaceous beds which we had already seen over a great extent of country.

The valley of the Arkansas is a river bottom, wide, level and easily irrigated; the descent of the river is about eight feet to the mile; the soil, where cultivated, yields abundantly.

The fall of rain is small and uncertain. The following table is constructed from an abstract of the meteorological register of Fort Lyon, kindly furnished me by Dr. Tilton, U. S. A.:

1861, 1st quarter.....	1.20 inches.
“ 2d “	5.14 “
“ 3d “	4.76 “
“ 4th “	0.15 “
1862, 1st “	0.19 “
“ 2d “	3.96 “
“ 3d “	2.57 “
1867, 1st “	0.60 “
“ 2d “	7.02 “

At Old Fort Lyon, as well as at the New Fort, and at some intermediate points, the lower cretaceous sandstone is exposed in thick beds, nearly horizontal, with a very slight dip to the northwest; it is of excellent quality as a building stone. In some places the exposed surfaces, as those of almost all the loose stones afterwards seen on the plains, are covered with a thin film of travertin, resembling whitewash.

Some of the beds of the quarry at Fort Lyon are very prettily variegated with red bands; ripple marks were frequently seen, and also nodules of sesquioxide of iron, but no fossils.

The sandstones at a distance from the river are overlaid with middle cretaceous beds of limestone and clay, containing, as on the Smoky, *Inoceramus problematicus*, *Ostrea* and shark teeth. General Penrose gave me a fine tooth of *Lamna* from shaly beds, twenty miles west of the fort. A bed of gypsum is said to occur near the river, forty miles west. Some wells dug about one mile and a half from the fort are contaminated with petroleum, but no useful supply of that material can be expected in the region.

§ 3. FROM LYON TO THE RATON.

The line surveyed runs through or near the valley of the Purgatoire, a permanent stream, affording at all seasons an abundant supply of water. The bottoms of the river valley, where cultivated by irrigation, give generous harvests. Dr. Sizer, our intelligent guide, informed me that on his farm he had gathered eighty bushels of Sonora wheat to the acre; and, in fact, the heads which he exhibited to me were very remarkable for size, both of the ears and the grains, and almost warrant belief in this enormous yield. Forty bushels of oats per acre were produced on the same farm. The edges of the stream are well timbered,

and the trees varied in kind; the cotton wood becomes interspersed with box elder* and black willow. The hills are crested with cedars, which towards the upper part of the cañon become mixed with pines of two species.

The stream flows for part of its course through a very narrow, deep cañon, with perpendicular sides. The rocks exposed on the banks, every place from the head of the cañon to the mouth, are the same early cretaceous strata as those at Fort Lyon. On the plateau each side of the cañon is a range of low hills of middle cretaceous limestone and marls, containing *Ostrea lugubris*, *Inoceramus problematicus* and fish teeth. The cañon is a narrow cleft in the cretaceous sandstone, whose direction appears to have been determined by an ancient fissure, the result of a very slight elevation. The immediate edge of the cañon is, therefore, higher than the surface of the plateau, and a shallow valley of drainage has thus been developed to the north of the river, somewhat parallel with it; the waters from this valley find entrance into the Purgatoire through side cañons joining the main cañon at right angles. Permanent pools of water were found in several of these side cañons, at convenient distances for camping.

In the deepest part of the cañon the erosion of the stream has gone entirely through the cretaceous sandstone, exposing the upper Trias or variegated marl series of Marcou and Newberry.† At this point, known as Red Rock cañon, a large bed of snow-white gypsum occurs; and, eight miles above, a bed of alum, described to me as being several feet in thickness. I obtained at Trinidad some small specimens from this locality, which I had not time to visit.

At the upper end of the cañon I found the sandstone very hard and slightly metamorphosed; in some places it contained leaves of exogenous trees; the specimens have been examined by Mr. Lesquereux, who finds them to belong to a species of *Rhamnus*, which is peculiar and has no affinity with any published from the tertiary, having a neuration still closer than that of a *Berchemia*. Some detached scars of a large reed, which Mr.

* Box elder is *Negundo aceroides* Moench, a common tree in Eastern Pennsylvania.

† Report of Ives' Expedition to the Colorado river. Geology, p. 78.

Lesquereux compares with those of *Arundo Goepperti*,* a European Miocene species were also collected.†

A small bed of coal is reported in the south side of the cañon about eight miles below the Red Rock. It has not been developed sufficiently to estimate accurately its thickness, but I have reason to believe that it is of no value. Specimens have been promised, but have not yet reached me.

In traversing the plateau north of the Purgatoire we passed near the base of a low ridge called the Black Hills. The strata were here disturbed, and the cretaceous sandstone in places much hardened. Very hard gray porphyry was seen, sometimes becoming yellow, sometimes black, on exposure. The crest of the hills is an abrupt cliff, a stratum of gray porphyry trending North eighty-eight degrees West, and dipping about seventy degrees towards the East.

Grass was very good along the whole of the region travelled over, where the soil was sufficient for its support. The hills of sandstone near the river are in great part surfaces of bare rock, supporting in the fissures a scattered growth of cedars.

In the lower part of the cañon of the Purgatoire a figure of a bear has been painted on the sandstone cliffs, on the north side of the stream. It is greatly revered by the Indians, who have no traditions of its antiquity, nor of the persons by whom it was painted. I visited the place and found the figure quite rudely drawn, though the accounts received from various sources had rather prepared me to expect a work of high art. The picture is dark brown, and some marks of the brush can still be traced, unless those parts in which I observed them are restorations by

* Heer, *Flora Helvet. tertiar.*, vol. i. p. 62, tab. 22, fig. 3 b.

† Mr. Lesquereux observes in his letter to me: "Drawing our conclusion according to the distribution of fossil plants related to those of Purgatoire cañon, we should have to consider these strata as referable to lower tertiary, rather than to upper cretaceous." The continuity of the sandstones from the variegated marls to the top of the cliffs along the extent of the cañon, shows that the whole mass must belong to the same series, viz.: that member of the cretaceous which overlies the upper trias; and the situation of the next members of the cretaceous in the bluffs of the plateau, each side of the cañon, confirms this view. It will be remembered that the early cretaceous flora of the Missouri, similar to that of Ellsworth, Kansas, was regarded for several years as tertiary by some of the most learned and accurate palæontologists.

more modern artists, when portions of the sandstone scale off from time to time under the influence of the frost.

Some rude figures of beaver and other small animals have been scratched on rocks near the bear, and I saw many little grooves in the stone, which I learned from Dr. Sizer had been made in sharpening the iron heads of arrows. Beads were scattered on the ground and in the crevices below the painting.

In ascending from the river to the mouth of Trenchera pass, the country gradually becomes more and more hilly, but shows no other rocks than the cretaceous sandstone overlaid by the middle cretaceous with its characteristic fossils. Some carbonaceous beds of small extent, and of no value, are here found.

At the mouth of the pass there is a large vertical trap dike twelve feet thick, which projects twenty-five or thirty feet in height, and is so regular as to appear like an immense Cyclopean wall. The direction of this dike is about South 60° West, but it disturbs the needle so much that I am not certain of the exact course. It can be traced along the hills for several miles in each direction.

On the opposite side of the Trenchera creek the hill consists of amygdaloid covered with earthy tufa; I could not trace the dike into this mass, though it was clearly visible far beyond it.

Two miles above the entrance of the pass, which derives its name from the wall just described, beds of cretaceous clay, covered with a lava stream and slightly altered near the surface of contact, are seen on the eastern bank of the creek.

The mass of the Raton mountain is composed of volcanic rock, basaltic in form, and rises in tremendous ranges of cliffs on each side of the Trenchera pass. The top of the mountain is a grassy plateau, with permanent lakes, the remains of the ancient craters from which poured the last floods of melted rock. At the summit of the pass we found a gently undulating plain, well supplied with springs, and covered with luxuriant grass. Some exposures of sandstone, slightly baked, sometimes brown, sometimes gray, were here seen; also, a few drift boulders of bluish granite from the Rocky mountains.

Beyond the pass the lines surveyed descend into the valley of the Canadian, here called Red River; the eastern part of this tract contain many ridges and cones, all of volcanic material, and are connected geologically with the great outflow of the

Raton. East of Trenchera pass, the mountain gradually becomes lower, and at about twenty-five miles breaks away entirely, leaving an undulating plain, strewn with volcanic rocks. Still further east the ground rises again into a table land called the Mesa de Maio, composed, as far as I could see from a great distance, of horizontal sedimentary strata, probably of cretaceous age.

West of Trenchera pass the volcanic mass of the Raton becomes still more solid and higher, being broken only by one well-defined pass, called Manco del Burro, which is too steep and uneven to be practicable for a railroad.

It is in this pass that the coal beds, so important for the future development of this region, first make their appearance. The reconnoissance of Mr. Eicholtz to the summit of the pass first established this fact, though no veins were at that time found. A few days later Captain W. F. Colton, visited the ravine near the summit, in which loose fragments of coal had been collected, and on the slope of the mountain observed three small beds, separated by thick beds of sandstone.

Neither the situation nor the thickness of these beds render them of value.

West of the Manco del Burro pass heavy beds of whitish sandstone appeared on the flank of the mountain, ascending slightly towards the west, and towards the Raton itself, which here culminates in some high basaltic cliffs, the most conspicuous of which is known as Fischer's Peak. The road does not pass over the sandstone hills above mentioned, but crosses several steep ridges, which contain beds of clay and baked rocks similar to those already described, which I believe to be cretaceous. Near Trinidad boulders of granite and gneissoid rocks from the Rocky mountains are abundant.

§ 4. TRINIDAD TO MAXWELL'S.

During this portion of the journey I examined the large coal beds of the sandstone formation mentioned in the preceding section; as will be shown hereafter, there is reason to believe that they occupy a much wider field than that in which the limited facilities of a reconnoissance enabled them to be studied.

It is also here that some of the most valuable agricultural inter-

ests, after passing the immediate valley of the Arkansas, can be developed. Already in the valley of the Purgatoire, from the head of the cañon to forty miles above Trinidad, a distance of seventy or eighty miles, the soil has been tested by farmers, and yields to their labor abundant harvests; the style of cultivation is rude, and modelled upon imperfect New Mexican methods. The river bottom is wide and easily irrigated.

South of the Raton Mountain the valleys of the tributaries of the Canadian, or Red River, as it is there called, present large tracts of land, which can be cultivated without difficulty.

I saw several fields of grain in the Vermejo valley, but the fine hacienda of Mr. Maxwell is the only one within this limit which has developed the agricultural richness of the country; as will be seen in the next section, other tracts are under cultivation between his hacienda and Las Vegas.

Before mentioning the exposures of coal examined by me, a brief description of the Raton pass is necessary. It lies in the valleys of two streams; the northern, called Raton creek, is a tributary of the Purgatoire, and is never dry; the southern is a small stream flowing into the Canadian, becoming dry at the lower part of the pass. The valleys of these streams lie to the west of the great basaltic cliffs which terminate the volcanic mass of the Raton, and are excavated chiefly in soft sandstones, though in the southern part of the cañon of the pass large loose blocks of pale gray eruptive rock are seen, which have a deceptive resemblance to limestone.

The western end of the Raton is enveloped to within a few hundred feet of the summit of the basaltic cliffs by the nearly horizontal beds of sandstone seen on the northern flank before reaching Trinidad. Though but little disturbed, these beds have a slight inclination upwards towards the Rocky mountains on the west, and towards the principal elevations of the Raton and the crest of the summit of the pass; the anticlinal indicated by the last mentioned slope has not, however, brought any of the subjacent rocks to the surface, the summit of the pass being of the same beds of sandstone as the hills each side of it.

The road is an excellent one for such a mountainous country, and is kept in good condition by Mr. Richard Wootten, the proprietor of the turnpike privileges granted by the Legislature of Colorado. The elevations are too great, and the slopes too abrupt to

enable the pass to be used for a railroad. The scenery is very fine, and were it not for the basaltic cliffs almost continually in view on the eastern side of the road, would remind the traveller of the ruder parts of the Apalachian chain. The hills are well clothed with good sized pine trees, which disappear again at the southern end of the pass.

Coal beds occur in the immediate valley of the Purgatoire, on Mr. Long's farm; I visited them in company with Mr. Eugene Liedendorfer and Judge S. M. Baird, and found the exposure only three feet thick, of which two and a half feet were of good quality. The bed examined lies between slatey clays, and can be traced a quarter of a mile up an arroyo, where it enters the cliff. The dip at the highest point was well marked, about 10° , direction S. 70° E. On both sides of the creek, above Mr. Long's, coal was seen, but the texture was more earthy. In all places the vertical cleavage of the coal was very distinct, sometimes extending into the neighboring slatey clays.

In the Raton pass, about one mile and a half from Trinidad, on the east side of the road, there are several thin beds of coal and carbonaceous clays of no special value. The upper bed is two and a half feet thick, of which one and a half feet, good; middle bed, three and a half feet, fair quality, but earthy; lowest bed, carbonaceous clay, three and a half feet. These beds dip N. 75° E., about 8° ; similar exposures were seen in the ravine running from Fischer's Peak. They are capped with yellowish sandstone; between the upper and middle bed I observed a stratum of gray clayey rock containing leaves and stems badly preserved. Mr. Lesquereux has determined them to belong chiefly to a species of *Abietites*, very closely allied to *A. Goepperti* Dunker;* some almost irre recognizable fragments seem to indicate a species of *Credneria*; both plants belong to the Quadersandstein of Germany, the middle division of the European upper cretaceous, which is the equivalent of the upper division of our middle cretaceous. Thus, in this instance, the evidences of the age of these rocks, derived from stratigraphic position, animal† and vegetable remains, all accord.

* Palæont., vol. iv, p. 180, tab. 32.

† I found at this locality a small *Inoceramus*, badly preserved in yellowish sandstone; it is indeterminate as regards the species, but confirms the views expressed of the cretaceous age of the formation; additional evidence is found in the pamphlet of Mr. Richard E. Owen, on the mines

The carbonaceous shales contain in this and other localities in the same formation from fifteen to thirty-five per cent. of ash, and are of but little value. The specimens of coal examined by Mr. Lesquereux and Professor Brush have six per cent., and the analysis by Messrs. Williams & Moss of other specimens shows only four per cent. of ash. The qualities of these coals will be fully discussed in another part of this report.

About six miles from Trinidad, on the east side of the road, on the bank of a small stream, an exposure in the bluff gave the following section :

Top of hill covered by drift,	— —	
Sandstone,	11 feet.	
Coal, 1 foot 6 inches	}	5 feet 2 inches.
Shale, " 7 "		
Coal, " 7 "		
Shale, " 6 "		
Coal, 2 feet "		
Slates,	4 feet.	
Mixed Slates and Sandstone,	4 "	
Coal,	1 "	
Sandstone,	0 "	10 inches.
Slates,	5 "	
Shaley Sandstone,	1 "	6 "
Sandstone,	12 "	
Slates,	4 "	
Sandstone,	1 "	
Slates,	3 "	
Detritus and bed of stream,	0 "	

The face of this section looks S. 70° W., the dip is about 10° S. 71° E.

Fifty yards further north I obtained the following section of the same beds :

Top of hill covered by drift,	— —
Sandstone,	12 feet.

of New Mexico, in the following passage, (p. 5,) referring to an examination of a coal bed near Trinidad, "just below a sandstone, which was, or had been capped by cretaceous, as we found a scaphite and an inoceramus."

Coal, (good,)	2 feet.	}	. 6 feet 10 inches.
Slate,	" 10 inches.		
Coal, (good),	1 " "		
Slate,	1 " 6 "		
Coal, (good,)	1 " 6 "	}	. 4 feet 6 inches.
Shaly Sandstone,	. . .		
Sandstone,	. . .		
Shaly Sandstone,	. . .		
Coal, (good,)	. . .	}	. 1 " 3 "
Slates and Detritus,	. . .		

These beds can be traced for three-quarters of a mile on the sides and in the floor of the arroyo, until they finally disappear below the surface. Above them other beds of small size are found at intervals nearly to the base of the mountain, a distance of almost two miles.

Indications of coal were seen at two other places between this locality and the toll-gate; but on digging, they showed only beds of clayey slate, bearing much carbon in some of the layers.

Near the toll-gate a bed has been excavated, but the working has caved in; my examination showed one and a half feet of coal, of which one foot is good, and six inches slatey. The bed is said to improve in quality and size farther in the bank. Some exposures of no value were seen on hills near the toll-gate. A bed about a quarter of a mile farther south is much thicker, and specimens from it of an excellent quality were given me. The opening unfortunately passed through a spring, and was partially filled with earth and water, so that I could not measure the thickness of the bed; Mr. Wootten, however, told me that the solid coal was about four feet in depth. Seventy-five feet higher, on the sides and bottoms of the ravine, about one-quarter of a mile distant, beds were exhibited as in the following section:

Debris on slope of cliff,	. . .	. — feet — inches.
Shale,	. . .	. — " — "
Coal,	. . .	. 3 " — "
Clay, slatey,	. . .	. — " 2 "
Coal,	. . .	. — " 7 "
Clay,	. . .	. — " 1 "
Coal,	. . .	. — " 9 "
Clay,	. . .	. — " 1 "
Coal,	. . .	. — " 8 "

The bottom of the slope was covered with debris from a land slide, and want of time prevented us from exposing fully the lowest bed of coal.

In crossing the summit, and on top of the hills each side of it, I observed that the upper strata of the sandstone are more micaceous than those which are nearer the coal beds.

Four miles south of the toll-gate, well down the descent to Red River, some coal appeared in a land slide on the east of the road, indicating a bed about three feet thick; ten feet below it is a bed of black slaty carbonaceous clay. A similar exposure was seen on the west side of the road, about one mile farther down. Indications less definite were seen near the deep cañon. The road-way is here narrowed by the cliffs to eighteen feet, and the sandstone rocks below this pass, called the Devil's Gate, are worn into fantastic shapes, figures of which would form a desirable addition to Doré's illustrations of Dante.

Mr. Wootten had told me of a coal bed in the neighborhood of the Devil's Gate; we searched for it during the afternoon and next morning, but without success.

An expedition over the hills on the previous day, in company with Mr. Wootten, to visit a coal bed eight feet thick, also failed. This bed is about five miles from the toll-gate, in a southwesterly direction, in one of the cañons which debouch into the Red River, south of Raton pass. We were unavoidably separated from our guide before arriving at the coal bed, but my later explorations convinced me that it is similar to those examined in the valley of the Vermejo.

The hills bounding Raton pass on each side descend abruptly to the plains. At the southern opening of the pass I observed below the sandstones thick beds of clayey material, but the necessity of hastening on our journey prevented me from visiting them. I inferred that they were similar to those seen along the Purgatoire, in which the small oyster, *Inoceramus*, &c., were contained; in other words, the lower division of the middle cretaceous; the coal beds would, therefore, be of middle cretaceous age, but more fossils must be obtained before their exact position in the lower or upper divisions (No. 2 or No. 3 of Meek and Hayden) can be determined.

The thick beds of sandstone, where not removed by erosion, continue along the base of the Raton eastwardly for a short dis-

tance. Along the base of the Rocky mountains they lie like an immense terrace, which extends as far south as the valley of the Ponejo, and perhaps even to the northern bank of the little Cimarón. The erosion of this terrace is in the form of deep narrow cañons, and the elevations between them constitute the eastern foot hills of the broad mass of mountains. The escarpment presented towards the plain is very steep. The strata are nearly horizontal, with but a slight dip in the general direction of the slope of the continent eastward.

These same beds, as observed in the preceding section, were seen extending northward from Trinidad, and were afterwards observed by me far towards the Arkansas. The coal of Cañon City on that stream, as described to me, is so similar in appearance and situation to the beds I examined in the Vermejo valley, that I have no doubt that it belongs to the same series, and that the strata of this formation lie uninterruptedly along the base of the mountains, from the Arkansas to Maxwell's, and fill up the broad valley, which would otherwise remain between the basalts of the Raton and the much older metamorphic rocks of the Rocky mountains.

At Fort Union I learned from Mr. Krönig that he had seen large coal beds in the sandstone strata between the Purgatoire and the Huerfano, and I think they may be expected to occur through the whole space occupied by this immense terrace.

Before reaching the mouth of the cañon of the pass, seeing some beds of carbonaceous clay, an excavation was made, but no coal of value was found; associated with them were two beds of heavy dark gray ferruginous stone, the upper one eight and the lower one four inches thick, similar to those afterwards seen in the cañons of the Vermejo.

Nine miles from the mouth of the cañon is Red River station, and twenty-five miles farther Vermejo station, where we encamped.

August 19. Bernard O'Donnell, the keeper of the stage station, accompanied General Palmer, Captain Colton and myself to the coal beds of the cañon of the Vermejo, from which supplies of coal are taken for the Government shops at Fort Union, and for haciendas as far as that post.

After riding five miles up the valley of the Vermejo, which has a regular and gradual ascent, we entered a cañon on the north side of the stream. We followed this cañon two and a half miles to

a coal bank, which is on the east side, about twenty-five or thirty feet above the bottom of the cliff. It shows ten feet of good coal, in two beds of five feet each, separated by ten inches of slate. Following the cañon above and below the bed, I obtained this section, in which the thickness of the strata is estimated by the eye, except where contiguous to the coal beds.

Sandstone from top of hill, about	. 800	feet — inches.
Clay,	5	" — "
Sandstone, with ferruginous beds, .	20	" — "
Coal, (partly poor,) and shales, .	10	" — "
Sandstone,	5	" — "
Calcareous Clay, (gray),	4	" — "
Ferruginous Clay,	2	" — "
Sandstone,	20	" — "
Coal, (partly poor,) and shales, .	15	" — "
Sandstone, laminated,	20	" — "
Sandstone, not laminated, massive, .	8	" — "
Shale,	3	" — "
Ferruginous Clay, indurated,	1	" — "
Shale, Slate and Clay, more carbonaceous below,	25	" — "
Coal, good,	5	" — "
Slate,	—	" 10 "
Coal, good,	5	" — "
Shales,	4	" — "
Ferruginous Sandstone,	3	" — "
Massive Sandstone,	20	" — "
Sandstone, more or less clayey, occasionally with well marked vertical cleavage,	80	" — "
Slates,	20	" — "
Sandstone to bottom of exposed rocks.		

The same bed, less perfectly exposed, is seen on the west side of the cañon, about half a mile above; near it are beds of a heavy dark gray stone, containing, according to an analysis by Messrs. Williams & Moss, 22 per cent of iron.

Carbonaceous shales are exposed in the main valley near the cañon.

Returning from the coal bank to the main valley, we ascended

it about three miles ; it became gradually narrower, and at length was merely a cañon, trending northwest. We saw in it several exposures of coal, which had been imperfectly opened, but as far as I could judge from the appearance of the contiguous beds of sandstone, they were parts of the same bank which I have described above. Iron ore and large quantities of silicified wood of exogenous growth occur at this place.

Similar beds are said to be exposed in other cañons of this valley ; and I afterwards learned from Mr. Maxwell that he had seen them also many miles above in the main valley. Time was pressing, and we reluctantly postponed further examinations to another occasion.

August 20. Captain Colton visited the coal bank in Blackmore Cañon, one of the northeastern branches of the Vermejo ; he procured specimens of the coal, which is of excellent quality, and kindly furnished me with the following section of the strata near the bed :

Sandstone,		7 feet — inches.
Slate,		1 " — "
Sandstone and Clay,		2 " — "
Sandstone, laminated,		9 " — "
Slate,		2 " — "
Coal,		1 " — "
Slate,		1 " — "
Sandstone, laminated,		5 " — "
Slaty Clay,		8 " — "
Sandstone,		2 " — "
Slate,		10 " — "
Ferruginous Sandstone,		2 " 6 "
Slaty Clay,		5 " — "
Ferruginous Sandstone,		2 " — "
Slate,		12 " — "
Sandstone, with ferruginous strata,		30 " — "
Slaty Clay,		1 " 6 "
Coal, (10 feet, not fully exposed,)		12? " — "
Sandstone to bottom of cañon,		— " — "

While Captain Colton was visiting the Blackmore bank, which is only four miles from Vermejo station, General Palmer and myself, in the guidance of Mr. O'Donnell, were exploring Bremer

cañon, the one immediately south of the Vermejo valley. Five miles west of the stage road we saw several exposures, mostly obscured by land slides; the best of them showed four feet of good coal; another of probably the same bed showed three feet. These beds seemed to be a continuation of those observed in the Vermejo cañons. Continuing our journey, we arrived at the hospitable residence of Mr. Maxwell about three o'clock in the afternoon.

§ 5. MAXWELL'S TO LAS VEGAS.

The high mesas resulting from volcanic outflows compel the railroad line surveyed to continue far east of the base of the mountains, which are at last approached near Vegas. The geology of the route is very simple. The early cretaceous sandstone (No. 1, Meek & Hayden) covered by middle cretaceous limestone and clayey marls, containing *Inoceramus*, *Gryphaea Pitcheri*, and other fossils peculiar to the period, occupy the surface, except where interrupted by volcanic mesas and remains of cones.

The very thick formation of sandstone, containing the coal beds described in the preceding section, ceases to skirt the foot hills of the mountain chain, and reappears no more in our southern progress.

The metamorphic ridges of the Rocky mountains approach more nearly to the plain, and so far as they have been explored, give evidence that they are as much loaded with mineral wealth as in the regions north of the Arkansas. Eighteen miles west of Maxwell's a valuable copper mine has been discovered, and has been well opened for future development. Specimens given me contain silicate, green and blue carbonates, and sulphurets of copper, making a very rich ore. Good specimens of argentiferous galena and iron ore, of the limonite and specular species were also presented to me, but without note of the precise locality.

Valuable placer washings of gold have recently been found in the same mountain ridge, which is the divide between the little Cimmaron and the Moro on the east, and the valley of Taos on the west. The excitement regarding the gold was becoming greater from week to week, and the last report that reached me on my return by stage, was that a party of five men from Colorado had taken out twelve hundred dollars in one day!

Whether this be true or not is of interest only to the supposed lucky individuals; but the aggregate quantity of gold collected in these placers, during a season when the small amount of water was unfavorable for such pursuits, proves the existence of most valuable deposits.

An association has been formed, and a route surveyed, to bring a permanent supply of water from a distance. It is expected that these works, at a cost of forty thousand dollars, will be completed by the time that the washings can commence in the spring.

I regret that want of time prevented me from making an excursion westward from Maxwell's to the base of the metamorphic hills to ascertain what strata are brought to the surface beyond the cretaceous. This portion of the structural geology of the mountain chain remains unknown, but I suspect from the similarity in the outline of the hills, that the strata involved in the uplift are the same as those which I afterwards observed near Vegas.

North of Fort Union a well wooded transverse ridge called Turkey mountain, is composed of upheaved sandstone of early cretaceous and older dates, and contains veins of copper and silver ore, as yet very imperfectly developed, and of doubtful value.

The hacienda of Mr. Krönig, about seven miles south of Fort Union, consists of large tracts of land, well cultivated by irrigation; the supply of water is obtained from artificial lakes, which are easily constructed in any part of the plains near the base of the mountains.

I visited with Mr. Krönig a supposed coal bed on the banks of the Sapullo, but found it to be merely a stratum of the worthless carbonaceous clay of the lower division of the middle cretaceous. Near it were found specimens of *Inoceramus* and *Ostrea*, as observed in other places. A hard blue limestone weathering into a snow-white surface, a member of the same group of rocks, occurs here, and when burned furnishes an excellent lime.

Mr. Krönig had under cultivation at the time of my visit about twenty-five hundred acres of land. The yield is good, being about thirty bushels of corn, forty of wheat, and fifty to sixty of oats to the acre. He was preparing still larger fields for irrigation next season, by lakes which he had recently made. I was told by him that the construction of these lakes had increased the quantity of rain in the vicinity, but no accurate observations have yet been made to determine the amount of this increase.

I received from Mr. Krönig, and Dr. Dubois, U. S. A., then at Fort Union, many interesting ores from the neighboring mountains.

The volcanic rocks, already so frequently mentioned, disappear near Fort Union; the most southern development of them seen are two low cones in sight from the fort. The largest is distant thirteen miles, N. 25° W., and has a crater about two hundred and fifty feet deep; the smaller is six or seven miles distant, N. 80° E., and has a crater about one hundred and fifty feet deep. Both craters are broken towards the south, and have emitted lava streams visible for several miles.

The permanent supply of water from surface drainage in this region is small, but the rain fall is quite sufficient, as shown by Mr. Krönig, for the formation of reservoirs. Natural cisterns are found in some of the valleys, in which there are no permanent streams; there are such near Fort Union, and they are of great depth.

Near Las Vegas the middle cretaceous clays and limestones are more developed than in the vicinity of Fort Union. The limestone is very hard, dark blue, and where exposed, is covered by a thin, snow-white crust, as mentioned by Dr. Newberry.* Near Las Vegas I found in this limestone fragments of *Inoceramus problematicus*. My explorations near Vegas have reference chiefly to the structure and contents of the eastern ridge of the mountain chain, which we for the first time approached, and may, therefore, be detailed in a separate section.

§ 6. LAS VEGAS TO ALBUQUERQUE.

The town of Las Vegas is situated on the Gallinas river, about four miles below the place where it emerges from the mountains. It is the third in importance of the towns of New Mexico, being surpassed in size only by Santa Fe and Albuquerque, but in business activity by neither.

The surface of the plains still continues to exhibit the cretaceous sandstone, covered with limestone and clay. Fossils are rare; as above mentioned, *Inocerami* occur in the limestone at Vegas, and in the underlying sandstone I found an indeterminate fragment of a reptilian bone.

* Report of Ives' Expedition, Geology, p. 106.

The cretaceous sandstone is highly inclined west of the town, and forms the entire face of the outer hills of the mountain chain. At the gate of the cañon of the stream it appears as a vertical wall, but the overlying limestone and clays of middle cretaceous date are undisturbed, ascending gradually, but slightly, towards the mountains, wherever they could be seen. Immediately inside, or to the westward of the sandstone, is a wall of very hard igneous rock, similar to those seen north of the Purgatoire, as mentioned in § 3; west of these are the marls, with gypsum beds, and the underlying sandstones, the saliferous beds of Newberry, now making their appearance for the first time in our journey.* They afterwards continued as our almost constant companions as far as Tijeras.

As seen in the cañon of the Hot Springs, these strata are all vertical, and their harder parts project like walls from the sides of the hills. Some of them furnish an excellent material for flagging, and are thus used in the streets of Vegas.

West of them, also vertical, is the immense thickness of metamorphic rocks, sienitic and gneissoid schists, which compose the eastern ranges of the mountains. No palæozoic rocks are seen between the dark-red sandstones and the gneissoid rocks, the carboniferous limestone, a conspicuous element in the mountain chain near the Rio Grande being here absent.

About one and a half miles west of the Hot Springs there are nearly vertical beds of iron ore. The eastern one is a stratified mixture of quartz and magnetic oxide four feet thick, and bearing, according to General Palmer's observations, N. 70° E., with a dip of about 80° to the South and East. One hundred yards north of this bed is a granite bed with red feldspar, six feet wide, carrying much specular iron, which is slightly titaniferous. A shaft was sunk fourteen feet upon it by Mr. Erminger, in the pursuit of other metals.

I learned from General Palmer that Mr. Erminger informed him that there was a coal bed three miles west of the Hot Springs; want of time prevented a visit to the locality. I learned after leaving Vegas, too late for an examination, that there is a coal bed six miles from the town, between Agua Sarca and Salitre, from which fuel had been brought for use in the blacksmith's forge

* Except for a very short distance in the Purgatoire Cañon, where the marl series with its gypsum bed is exposed by erosion,

when Vegas was a military station. I have written for specimens, which I hope to obtain before the publication of the final results of the survey.

The Hot Springs are situated on the southwest bank of the creek, and are quite numerous. Some fourteen to twenty are known, of which a few flow into the stream, while others merely moisten the ground for a few feet. The temperature varies, depending on the freedom of exit for the hot water, none being above 140° F. The waters are very slightly sulphuretted, and bubbles of sulphydric acid gas are continually evolved. The water, whether hot or cold, is nearly tasteless, and makes a very slight deposit on the rocks; it seemed to me to contain no active mineral ingredient. Thick masses of *confervæ* were seen in each of the springs, as is the case in other localities of thermal waters.

The fame of these springs has spread throughout New Mexico, in consequence of their remedial powers in venereal diseases; ailments which, from the confusion of moral ideas in the minds of the natives, are unfortunately, as in other Spanish countries, very prevalent. Other Hot Springs in the Rio Grande valley enjoy a similar reputation, but not to the same extent. Their virtue probably depends simply on the eliminative and depurative effect produced by the increased secretion from the skin, caused by the frequent use of hot baths.

A few miles south of Vegas we entered the mountain system, by passing through a narrow break in the eastern range of hills, which consist of highly inclined cretaceous sandstone. The pass is called the Puertocito del Padre; west of the outer range of hills, the red sandstones and marls of the Trias appeared, and the line follows a valley excavated in these soft materials, which lie horizontally. This valley gradually becomes wider and wider; towards the west the ground is gently undulating, with rounded hills, resembling our own well wooded hills of the Atlantic States. On the west the disturbed strata have been passed, and the bluff gradually becomes higher as we descend the valley, presenting the section of a mesa of cretaceous sandstone underlaid by the marl series of red, white and greenish strata of the Trias. Whether there be any Jurassic strata between the Trias and cretaceous has not been ascertained, on account of the absence of fossils; though, judging from the entire conformability of the strata through a very large region, it is very probable that the

upper beds of the marl series may be eventually classed with the Jurassic. The thickness of such formation is not great, and it cannot practically be distinguished from the beds beneath.

A fine exposure of the marls, capped with early cretaceous, is seen near Tecalote creek; many such were afterwards seen, but this being the first, I requested Mr. Gardner, our skilful photographer, to make a picture of it, which he has done very successfully.

Large beds of gypsum are found in the Trias, and many localities were seen by me in this neighborhood.

Tecalote creek, having eroded through the marl series, is now bedded in a hard, white sandstone, called upper saliferous by Newberry. It is a deceptive rock in appearance, and frequently cannot be distinguished from the lower cretaceous, unless the relations of the strata are seen.

A beautiful little fall over a cliff of this sandstone, not more than one-quarter of a mile above the camp, gave us one of the most delicious bathing places I have ever seen, and was fully enjoyed by our party during the few days that the camp remained fixed.

The country from Tecalote to the Pecos is very much broken by erosions through the marls and upper saliferous sandstone, and seemed to present great difficulties, which vanished under patient and skilful exploration. Geologically it is of small interest; the strata along the line are Trias, exposing here and there beds of gypsum; the high mesas, with abrupt sides, expose beautifully the marls, capped with cretaceous sandstone, as described by Newberry in Apache cañon. In the descent to the Pecos these become lost, except in distant views, and the surface becomes bare and rocky; the river here cañons the pale saliferous sandstone already mentioned at Tecalote creek. The cañon is abrupt, with perpendicular walls, and is joined by many side cañons from each side.

Near the house of Salazar, between Tecalote creek and the Pecos, is a gypsum bed, and a deposit of tufaceous limestone, or travertin, similar to those which occur in many places further on.

Near Taylor's ranch, at Ojito del Apache, and on the Pecos river, below our crossing, are carbonaceous beds, but from what I could learn they are thin and irregular. Specimens were promised me, but have not been received.

In the pale saliferous sandstone no fossils were observed, except

in one bed, near the Pecos, and again in a stratum exposed in Cañon Blanco, where some stems of *Stigmaria* were found, thus fixing the age as Palæozoic. Some *Calamites* obtained from the same rock at Pigeon's ranch, east of Santa Fe, determine it, according to Mr. Lesquereux, as lower Permian.*

The bare surfaces of the sandstone near the Pecos river weather into slightly concave spaces, and the rock in some places shows a nodular structure; the low hills on each side of the cañons are rounded in outline, and composed of fragments of limestone, with yellow or bluish calcareous argillites, covered in part with tufa; fragments of the red triassic marls and bluish calcedony are intermixed. A few pieces of obsidian were also found.

The rain fall during the past season was less than usual in the country south of the Pecos; some lagunas, usually permanent, which we expected to find before reaching the small pools of the Cañada de los Diegos, were dry, as was also the laguna on top of the hill southeast of our camp in the Cañada.

About half way between Cañon de Fileto and Cañada de los Diegos we passed Puerto Capote, after which the soil became sandy and covered with an open forest of large pine trees. The strata are much disturbed at that place, and the dark red sandstone (lower saliferous of Newberry), is exposed. West of the road the hills are a flat mesa of Trias, capped with yellowish cretaceous sandstone.

The upper rocks lie horizontally in Cañon Blanco; the red sandstone forming the floor of the cañon is in places disturbed.* At the rise of the hill by Cañon del Toro, in ascending the mesa, the upper rocks, including the cretaceous sandstone, are disturbed. The slope of the hill is red sandstone, with patches of tufaceous limestone. The top of the mesa is an undulating plain, covered with good grass; the ridges are crested with cedars and piñones as far as the Lagunas Coloradas.

This undulating plain descends gradually to the west, and is destitute of water, but produces good grass, and has many hollows, which, by damming, would easily be converted into permanent reservoirs, similar to the Lagunas. At the Sejita de Sunier

* *Vide* § 8, *infra*.

† This same nonconformability of the two divisions of the saliferous system was observed by me afterwards in Apache Cañon. *Vide* § 8, *infra*.

there is an abrupt break towards the north, exposing mesas of the marl series, capped with cretaceous, and well clothed with trees similar to those above mentioned. Drift pebbles and small boulders of hornblende schists were here seen.

Descending slightly from this elevation, the undulating plain, destitute of water, still continues, and rises again, forming a summit at the southern base of Monte Largo, which is the southern mass of the mountain chain consisting of it and the two Placer mountains. The carboniferous limestone here first appeared, dark blue and somewhat argillaceous.

The fossils, both here and along the line surveyed, are less perfectly preserved than farther north in the Zandia and Santa Fe mountains. The distance between the waters, (34.4 miles,) and the consequent suffering of the horses in the intense heat, prevented as close an examination of the relations of these rocks with the mountain mass as I desired to make.

The valley of the Aguajes exhibits only the dark red sandstone previously mentioned. These rocks were disturbed, showing slight elevations, which appeared to be minor axes bearing northwest and southeast, thus being approximately at right angles to the chain of Monte Largo and the two Placers. Each of these, however, are broad groups of hills, in which it is difficult on a superficial reconnoissance to detect any principal axis, the direction of which can be measured.

In a small anticlinal, northeast of camp, I determined the plane of the vertical cleavage of the red sandstone, to be nearly N. 10° W., indicating some of the principal disturbances to have taken place along that direction. I also observed that some of the small boulders of drift pebbles, similar to those of the Sejita, were covered with a tufaceous deposit.

One bed of the dark red sandstone had at first sight almost the appearance of amygdaloid, owing to the conversion of the shells that it formerly contained into calcite, but the outline of the fossils was destroyed past recognition.

The next day (September 18) I rode past San Antonio to Tijeras. Before arriving at San Antonio I saw a large deposit of snow-white gypsum on the east of the road, in its usual position at the lower part of the horizontal marl series.

The rocks were red and indurated, and the bed of the arroyo

was filled with large blocks of carboniferous limestone of a blue color, containing fragments of *Encrinites* and *Bryozoa*.

Near Mr. Carpenter's a shaft had been sunk into the dark red sandstone in quest of copper ore, but no satisfactory result was obtained, though the cracks of the rocks were tinged with blue and green carbonates. A similar indication of copper is seen one-quarter of a mile east of Carpenter's.

An excellent copper mine is now being worked about one and a half miles east by south from Tijeras. The vein is in carboniferous limestone, and the gangue is calcite and magnesian clay ("soap rock.")

It is nearly vertical, and bears N. 10° W.,* with a thickness varying from one and a half to two and a half feet. The ores at the surface are green and blue carbonates, silicate, then red and black oxide, becoming at a greater depth sulphuretted. Both the copper pyrites, variegated copper and copper glance are found, all in a very compact and scarcely crystalline form.

As early as 1843 much ore was taken from a pocket adjoining this vein by a Frenchman whose name I could not learn.

On the main mass of Zandia mountain a large outcrop of white Kaolin is visible from Tijeras; near it are several fine springs.

Many veins of argentiferous galena occur in the Zandia mountain. They are of small size on the surface, but may be expected to unite and grow larger below.

Coal of a good quality is found a short distance from Tijeras, south of the cañon; the thickness of the bed is not known, but I hope to have it properly explored in time for the results to be used in a final report.

From the Aguajes, and in riding along the San Antonio valley, the rocks of the Zandia mountain present slopes, rising towards the Rio Grande, and extending to the top of the mountain, which have been eroded by the lines of drainage. I judged from the outline of these slopes that the carboniferous limestone and the overlying dark red sandstone were nearly, if not quite, conformable.

The next day (September 20), after examining the Tijeras mines, I rode to Albuquerque, through Cañon de Carnuel. The scenery is very grand, the hills bold in outline, and the exposure

* Compare the bearing of the cleavage of red sandstone at Aguajes.

of rocks tremendous. The trees gradually disappear from Tijeras westward, until the mountains seem perfectly bare, except where clothed with patches of low vegetation in the valleys near the summit.

The cañon seems to have been eroded in part along the junction of the red sandstone and limestone with the metamorphic rocks. The hills south of the pass are much lower than the main mass of the mountain northward, and the red sandstone is quite conspicuous on the top of them; as I rode through the cañon I saw beds of green pyroxene schists, (serpentinoid trap of Marcou?)* and gray gneissoid granite, evidently stratified, containing masses of a darker, more micaceous rock. As nearly as I could estimate, there was evidence of three different reconstructions of the material of these rocks.

At one point on the south bank of the stream the gray granite is composed of immense boulders, which contain smaller masses of darker micaceous rock, connected by intervening curved layers of stratified gneissoid material.

High up the mountain slopes, towards the north, appeared cliffs of red granite, which showed no trace of stratification.

The red granite is composed of red orthoclase, green pyroxene and white quartz, and is very coarse in texture. It appears to be quite free from mica.

The gray granite contained many veins of white feldspar, and the newer recompositions of it appeared to be more easily disintegrated than the original rock.

In the bed of the stream the boulders of sandstone and limestone gradually become smaller, and finally give place to stratified earth. No exposure of rocks was seen on emerging from the cañon, but only hills composed of detritus of gray granite, with occasionally a pebble of limestone.

The view of the western face of the Zandia mountain from Albuquerque is one of the most beautiful I have ever seen. The tints and shadows change with every hour of sunlight, each exhibiting new beauties, and to the student new reflections, as the ever varying light develops features before unobserved in the complex topography of the mountain slope.

* Explorations for railroad routes from Mississippi to Pacific, vol. iii. Geology, p. 32.

At the top of the mountain is seen a nearly horizontal exposure of the edges of the strata of carboniferous limestone, easily distinguished from the subjacent rocks. Then follow a series of perpendicular cliffs of red granite, apparently unstratified, and at the base of these the gray granite, in the form of a gigantic talus, or slope, deeply eroded by narrow branching valleys, in which the vivid green of the grass and shrubbery contrasts charmingly with the neutral tints of the rocky slopes.

From Albuquerque I made a journey to Santa Fe, and afterwards examined the mines of the Placer mountains. Although a description of them interrupts the continuity of my reconnoissance, a section must be devoted to that purpose, with such other collateral information concerning mineral resources, as seems worthy of mention, before proceeding with the observations made along the line surveyed. I shall postpone to another part of the report reference to the agricultural resources of the valley of the Rio Grande, now rudely and very partially cultivated, but capable, under a proper system of irrigation, of supplying the wants of a large population.

§ 7. ALBUQUERQUE TO SANTA FE AND RETURN.

It is proper to acknowledge in this place my obligations to many citizens both of Santa Fe and Albuquerque, for the kindness with which they communicated to me the knowledge they possessed regarding localities of minerals, likely to be of value in the future development of the country, and for the generosity with which they gave to me whatever among the specimens they had collected that seemed likely to aid me in my investigations.

Mr. Zeckendorf informed me of the existence of numerous veins of galena in the Zandia mountain; and of copper ore and a very large deposit of sulphur at Jemez; I received from Mr. Textor carboniferous limestone containing *Athyris subtilita*, from the same place; in the same region is a large calcareous spring, which rapidly deposits tufaceous covering upon any objects placed in it. There, too, are hot springs, reputed to be equal in virtue to those of Vegas.

I obtained from Colonel Watts, U. S. V., in Santa Fe, specimens of coal similar to the other coals of the Rio Grande valley, from Tierra Amarilla, one hundred and twenty miles northwest

of Santa Fe; micaceous iron fifty miles north of Santa Fe; and specimens from various gold and silver mines.

On the road to Santa Fe, *via* Algodones and La Vejada, I observed nothing worthy of note at the present time, except the gigantic lava stream at the place last named. Black or dark brown in color, very tough and compact in texture, it skirts the valley on the north, forming a steep bank several hundred feet in height; it thins out towards the east, covering the variegated marl series, which is exposed in the cañon along the side of which the road makes a steep and difficult ascent. The remains of the crater may be seen on the top of this volcanic mesa, and the lava in many places is covered with tufaceous incrustation.

Other such volcanic mesas are so numerous in the valley of the Rio Grande as to be scarcely worthy of mention in this report; and volcanic cones abound in the valley of Santa Fe, especially towards the Placer mountain. None of the outflows are as large as that of Vejada.

I may observe in passing, that a lava stream exists opposite San Felipe, and will be found a formidable obstruction to a railroad crossing at that point.

At Santa Fe I collected some excellent specimens of the fossils in the carboniferous limestone, here represented by a flesh-colored crystalline marble, which, when polished, is quite ornamental. These fossils have been previously investigated, and prove the rock to belong to the middle carboniferous or true coal measures. The lower carboniferous does not exist in this region, and the upper is represented only by the dark brown sandstone above described (§ 6), which is completely destitute of fossils. No coal is to be expected in this formation, or in fact in any of the beds underlying the cretaceous.

On my return I saw at the northern end of the Placer mountain, a group of volcanic mounds, extending towards the Rio Grande; the smallest and most northern of them is a rocky cone, which contains in pale lava, veins of turquoise, the Aztec chalchuitl, extensively mined in former ages by the Indians, and highly prized by them, though of too poor quality to possess commercial value.

At the northern end of the Old Placer mountain is situated the Ortiz mine and mill. In company with the attentive superintendent *pro tem.*, Mr. Krouse, I visited the works, a five stamp

mill moved by steam power. The ore is quartz with much sesquioxide of iron, is easily crushed, and yields an average of twenty-seven dollars per ton in gold. The vein bears N. 13° E., and is nearly vertical. In the deeper parts of the mine pyrites has commenced to appear, but in the upper portion it is completely decomposed.

Before arriving at the mine I observed near Galisteo creek great quantities of silicified wood, derived probably from the trias; the rocks are much disturbed, the variegated marls, and lower cretaceous sandstone being highly inclined and contorted. The yellow coarse sandstone is worn into fantastic forms, and the fissures in it are tinged white by metamorphic action; I found here a small trachyte dike, only four inches wide.

The upper stratum of this cretaceous sandstone, as at other places, contains many pebbles, and is of very coarse texture.

Within one mile and a half of the Ortiz mine immense quantities of magnetic iron ore are found; copper ore also occurs in the neighborhood. Other exposures of gold-bearing quartz are known, but not yet worked.

Four miles northwest of the mine is a coal bed, which by the overflow of a lava stream, now congealed into gray porphyry, has been converted into a substance resembling anthracite, but much lighter and more brittle than the anthracites of the older formations. This phenomenon is not unique, as has been supposed by some visitors to the mine; the same thing has occurred in the tertiary coal beds at Meissen, in Prussia (late Saxony); the upper strata of the tertiary lignite, by contact with melted rock, have become hard, lustrous and brittle, appearing, in fact, precisely like the New Mexican anthracite.

I obtained the following section of the rocks at the locality; the strata are inclined from 25° to 30° nearly East, (magnetic), and the cleavage of the coal is vertical, bearing South:

Top of hill gray porphyry, composed of orthoclase, with small crystals of black hornblende.			
Yellow Sandstone,	.	.	12 feet.
Alternating Sandstone and Clayey Shales, somewhat baked in places,	.	10	" 6 inches.
Anthracite,	.	1	" 6 "
Anthracitic Metamorphic Slates,	.	1	" 6 "

Anthracite,	.	.	.	.	.	2 feet, 6 inches.
Shales,	.	.	.	.	.	6 " 6 "
Anthracite, (bottom of bed not seen),	—	"	14	+	"	
Shales and slope of Detritus to bot-						
tom,	.	.	.	.	.	— " — "

On the opposite (eastern) side of the narrow ravine, the gray porphyry and sandstone, with ferruginous layers, occupy about sixty feet, then the yellow sandstone to the bottom. The lower portion of the cliff of eruptive rock is concealed by fallen fragments, so that I could not observe the contact with the ferruginous sandstone.

The same coal bed is exposed about one and a half miles distant, but according to a specimen collected by my assistant, Dr. Parry, has been much less affected by heat.

In the arroyo, before arriving at the coal mine, I saw beds of carbonaceous clay, and also of iron ore; one of the latter about one foot thick, is of good quality, and contains 36.49 per cent. of metallic iron. It seems to be a partially oxidized carbonate.

The variegated marls are exposed a short distance northwest of the arroyo, highly inclined towards the east, as at the place near Galisteo creek, above described.

I sought for impressions of leaves in the shales of the anthracite, but found only one very imperfectly preserved; it is recognized by Mr. Lesquereux as belonging to a species of Palm, of the genus *Sabal*, concerning which he observes, "Sabal species are common in the Miocene of Europe, and also, as said above, in the great lignitic formation of Mississippi and Tennessee. But remains of the same kind are found also in the coal-bearing strata of Nanaimo, Vancouver Island, which, by relation of general flora, I referred to tertiary, but which Dr. Newberry considers as cretaceous. The color and peculiar composition of the stone from Placer mine is much like that of Nanaimo; the flora of Nanaimo has more species of old types than that of the Mississippi. Therefore, from this scarcely acceptable bit of evidence, I would consider the Placer coal as inferior in position to the Marshall formation (near Denver), and probably belonging to the most recent cretaceous than the oldest tertiary. My idea is that the Placer mine coal is intermediate between Marshall's and

the Ellsworth formations. I say the same of the shales marked Raton pass."

Mr. Krouse kindly promised to have search made for other specimens of leaves, which, as he told me, are occasionally found in great perfection.

From the proximity of the marl series, the absence of all characteristic upper and middle* cretaceous shells, and the known† existence of lower cretaceous lignites west of the Rio Grande, I infer that the anthracite bed belongs to that period, and that all the beds of which I have information along the valley are of the same age.‡

Pursuing our journey from the Ortiz mine southward, we passed the mines of the new Placer mountain, which are numerous, and perhaps still more valuable than those of the old Placer, though as yet but feebly developed. A specimen of yellowish white tufaceous material from the Candelaria mine gave, on assay by Messrs. Williams & Moss, seven hundred and thirty-eight dollars and eighty-six cents gold, and seven dollars and fifty-four cents silver per ton of two thousand pounds.

A land slide of great extent is visited by the natives every year during the rainy season, when water may be found in the neighboring ravines, and yields to each workman from four to ten dollars per day. The estimate of the value of this land slide, among intelligent inhabitants, is from 8 to 12 dollars per ton.

A small bed of coal ten inches thick is found one mile from the Hutchinson gold mine of the new Placer, but neither its size nor its position entitle it to attention.

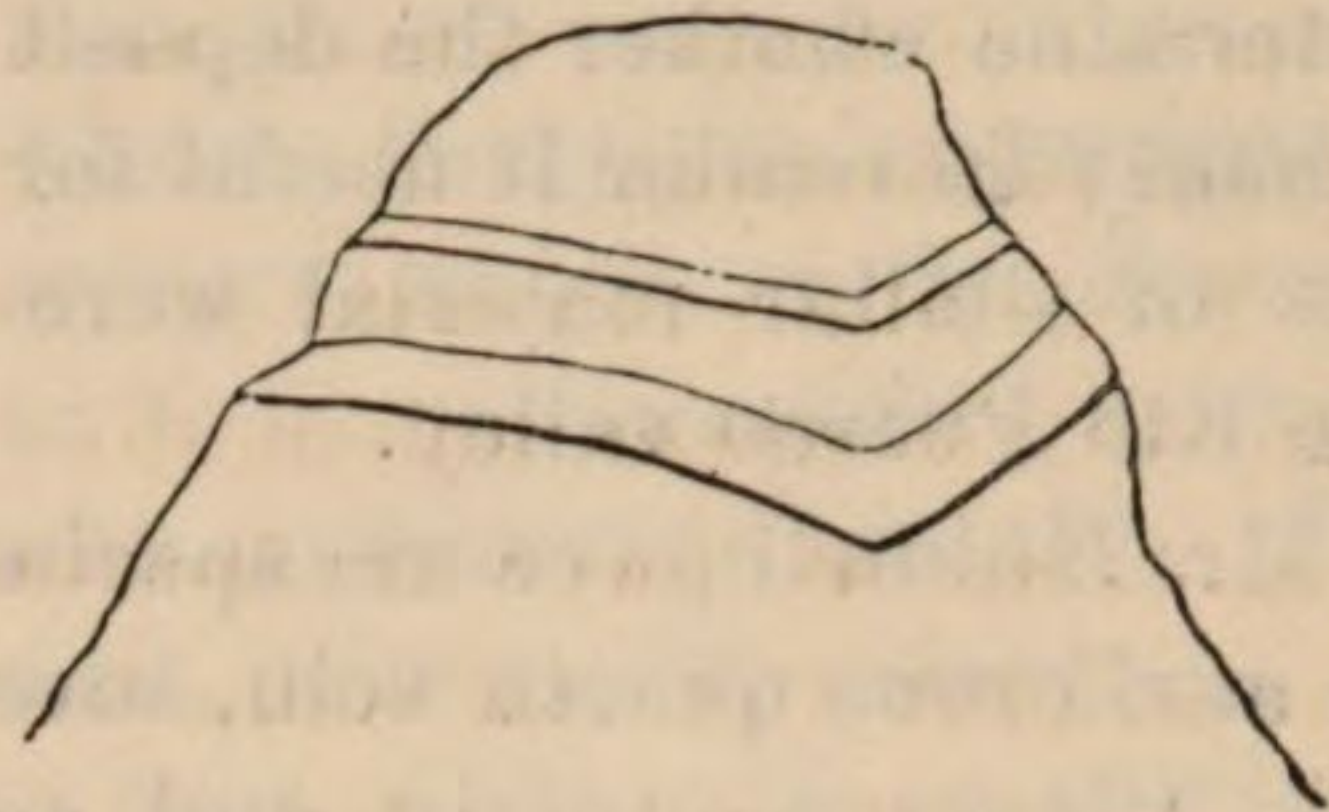
Carboniferous limestone appeared on the surface near the Hutchinson mine, and can probably be traced around the entire groups of mountains known as the old and new Placers, which are connected together, so as to form a broad mountain chain. They consist chiefly of porphyritic and sienitic hills, and where traces of stratification remain, the planes are highly inclined. At the northern part of Monte Largo, a group, in part at least, of the same nature as the Placers, and continuing the same

* I must again remind the reader that the terms upper, middle, and lower cretaceous are used in a local sense; all the strata contain fossils similar to those of the European newer cretaceous.

† Newberry, in Ives' Report, Geology, p. 84, et seq.

‡ Conf. U. S. and Mexican Boundary Survey, vol. i, Geology, p. 35, on the cretaceous age of the lignites of the lower Rio Grande.

broad mountain chain, I observed two mountains apparently capped with carboniferous limestone, and the superjacent brown sandstone. On the more eastern of these two mountains the strata dip to the east, on the other they lie nearly horizontally, with an abrupt twist, visible on the southern side, thus:



The superficial gold deposits of the Placer mountains are very extensive, and moderately rich; but there is not enough water to work them with advantage, except during the rainy season. On the mountain slopes in the deeper ravines springs are not unfrequent, and I think that by judicious boring water might be obtained in greater quantities.

Below the Ortiz mine there are several fine springs, and I see no reason why, with proper exploration, other equally favorable sites for mining purposes may not be found.

I received from Colonel Watts, at Santa Fe, some specimens from the coal bed south of Tijeras. I was not able to visit the locality, but the specimens, though taken from the surface, seem to be similar to those from the bed east of Don Pedro, near Fort Craig, and of equally good quality.

§ 8. ALBUQUERQUE TO FORT CRAIG.

Leaving Albuquerque on the afternoon of September 28, we rode to Mr. James Hubbell's, eight miles below the town; a beautiful and well cultivated hacienda, on the west side of the river, with a commodious house, combining the appearance and comforts of an Eastern country residence more than any other place I visited in New Mexico.

Mr. Hubbell had kindly procured for me specimens from the coal beds twenty-one miles west of his hacienda. They are situated in the valley of the Rio Puerco; the exposures are about five feet thick, and the dip about 35° northwardly. One exposure was worked some years ago to a moderate depth, but the excavation has since caved in, so that only surface specimens can be obtained. Those given me are dull black, without lustre, and contain much yellow resin diffused in small particles. I

have seen similar specimens among the tertiary coals of Germany; the fuel is far inferior to what is obtained from other localities mentioned in this report, and exploration alone will determine whether the deposit will improve at great depths sufficiently to render it useful for railroad purposes. Other localities of similar material were mentioned to me as occurring in the Rio Puerco valley.

Mr. Hubbell gave me specimens from the mammoth gold lead, an auriferous quartz vein, seven feet wide. It is situated in the new Placer mountain, and, as I was informed, has been traced and claimed for seven thousand feet. The general bearing is a little East of North. The specimens have been assayed by Messrs. Williams & Moss, but yielded no gold or silver.

At Los Lunas I received from Dr. Henry Hilgert specimens of supposed gold rock from Cañon de Agua and the Sierra de los Ladrones; in neither of the specimens could Mr. Moss detect gold or silver.

Volcanic mounds were seen on the road; one west of Padilla and Isleta; the other behind Los Lunas. They have sent out lava streams, which now limit the western side of the river valley by their escarpments of hard and tough basaltic rock. The wells at these towns, as in other places in the river valley, are from twelve to fifteen feet deep; the water is abundant and good.

The high mesa, above the river valley from Albuquerque down to the Puerco, as well as above Albuquerque, is of stratified sand; below Belen, and generally in the vicinity of the volcanic mounds, this stratified sand is capped with a white layer of tuffaceous limestone, which does not appear to enter the inequalities exposed in the sections of the bluffs, but was deposited on the surface, after the final action of the eroding forces. Below this mesa is seen the river terrace, also sandy. Near the Puerco, the river terrace disappears, and the high mesa is eroded to a low point.

On the summit of the Manzana mountain, east of the river, I observed the same stratified rocks that are exposed on the western face of the Zandia mountain, of which the Manzana is the southern continuation. So far as I could judge from such a distance, the eastern slope of the Sierra de los Ladrones is chiefly, if not entirely, porphyritic.

I was informed by Dr. Harnit, a partner in the Government Agency at Limitar, that a good bed of coal exists near that town. I was unable to procure specimens or to learn the precise situation of the exposure.

Near Socorro is a mountain, Sierra Madalena, composed of variegated marls, capped with porphyry, which, at the distance from which I viewed it, appeared to be in part stratified, perhaps sedimentary rocks altered in place by metamorphic action. The dip seemed to be about 15° westward, or from the river.

A bed of coal is known at the base of the hills, west of the town; fragments of good quality are frequently found in the arroyo, but no excavations have been made to determine the size or extent of the bed.

I remained one day at San Antonio to visit the coal mine from which the fuel for Fort Craig is obtained. It is eight or nine miles east of Don Pedro, the small town opposite San Antonio; the exposures are situated in a group of small hills composed of lower cretaceous sandstone, dipping 10° to 12° East.

I obtained the following section in an examination which was very brief, from the necessity of returning to San Antonio that night:

Indurated Clay and Sandstone to top of hill.

Carbonaceous Shales, with beds of Clay,	2	feet	6	inches.
Coal,	1	"	6	"
Slate,	—	"	3	"
Coal,	2	"	6	"
Gray Slate with Pyrites,	—	"	3	"
Coal,	1	"	6	"
Indurated brown Clay,	—	"	—	"

Dip about 12° , bearing S. 30° East; cleavage nearly vertical.

North of the coal beds the hills consist of yellowish sandstone running under the coal, and having the same dip and direction.

Southwest of the coal bed about one quarter of a mile, is a heavy bed of conglomerate, containing porphyritic pebbles with others of gneissoid, sienitic and sandstone rocks; it contains small veins of calcite, bearing northeast. Below this bed of conglomerate is a permanent pool of water, the only supply known in the vicinity.

The limits of this deposit of coal are not yet ascertained.

Several exposures of the same size and quality as that which is mined have been found in the group of small hills, but have not been developed.

In the sandstone above the coal is a bed of highly ferruginous sand rock nine inches thick, not sufficiently rich to be worked as an iron ore; middle cretaceous limestone containing *Inoceramus* is also found within three-quarters of a mile.

Veins of copper, specular iron and galena occur in the neighborhood. Specimens have been promised me, but are not yet received.

This coal mine can be worked for many years. Three drifts have been made along the course of the bed; the deepest is about three hundred and fifty feet in length.

The lower terrace of the river valley consists of horizontal tufaceous strata, partly white, partly brown. The range of high hills northeast from Don Pedro contains variegated strata looking like the mesas of trias covered with lower cretaceous mentioned in a previous section, and are not capped with igneous rock. These strata have a moderate dip towards the east, or from the river, and contain the usual beds of gypsum.

South of San Antonio the river bluffs consist of brown clays, capped with a loose clayey conglomerate.

Opposite Fort Craig there is a very high mesa capped with rock, and from the road a few miles north of the post the volcanic cone which poured forth this great lava stream can be distinctly seen on the top of the mesa.

On my return from Fort Craig to Trinidad I had an opportunity of seeing the magnificent sections of Apache Cañon described by Dr. Newberry,* where the erosion has exposed all the strata from the lower cretaceous sandstone down to the middle carboniferous limestone. Colonel McClure gave me a specimen of a *Calamite* from the white sandstone of Pigeon's ranch, which is the same bed as that from which I obtained the *Stigmara* of Cañon Blanco. Mr. Lesquereux has determined it as *C. Suckowii* Brongniart, a species characteristic in Europe of the upper carboniferous and lower Permian. A specimen of *C. leioderma*, indicating the same formation, was given me at Fort Union by Dr. Dubois. I did not learn the exact locality; the specimen is re-

* Ives' Expedition, Geology, p. 105.

markable in being charged with copper, like some of the European Permian fossils; the copper ore of Jemez contains vegetable remains, but the fragments given me were so small as to be irrecoznizable. The evidence is, therefore, conclusive, that the dark brown and the white sandstones lying between the carboniferous limestone and the gypsiferous marls are of palæozoic, and not mesozoic age.

It was evident in various places that the dark red or brown sandstone is not conformable with the white sandstone which lies above it. This white sandstone, however, and all the marl series, and the lower cretaceous sandstone lie conformably.* There has, therefore, been at the end of the period, probably upper carboniferous, during which the dark brown sandstone was deposited, an important disturbance in the surface, resulting in the elevation of the mountain chain immediately east of the Rio Grande, with parallel waves of elevation of less magnitude towards the east. This phenomenon was afterwards repeated in a more northern and eastern region at the end of the period during which the lower

* The observations mentioned in the text, as well as the deductions therefrom, in part iii, of the present report, are confirmed by the following remarkable extracts from a memoir by Messrs. Meek & Hayden, entitled "Description of new organic remains collected in Nebraska Territory in the year 1857," &c., which is printed in the the Proceedings of the Academy of Natural Sciences, of Philadelphia, for 1858. The passage quoted is found on p. 45.

"Indeed the general aspect of No. 1," [lower cretaceous of the present report], "and that of the formations below, are so very similar, and they are all so unlike the beds above, that if we were to classify them by their lithological characters alone, we should be inclined to view No. 1 and formations A, B and C as forming one natural group, or at least to think that portions of No. 1, as we now understand it, should be classed with the series below. This view also appears to be the more reasonable, when we take into consideration the great thickness of No. 1 in the vicinity of the Black Hills, and the fact that the beds A, B and C contain a group of fossils apparently more nearly related to lower than to upper Jurassic forms.

Inasmuch, however, as numerous leaves beyond a doubt belonging to dicotyledonous trees . . . are known to occur in No. 1, . . . we think we hazard little in viewing at least a considerable portion of No. 1 as belonging to the cretaceous system." And again on p. 46, ". . . . to indicate that the last period of disturbance among the strata of this region occurred after the close of the cretaceous epoch, but previous to the deposition of the tertiary."

cretaceous sandstones were deposited, as has been heretofore shown by those strata and the subjacent ones being vertical, or highly inclined at Vegas, while the middle cretaceous limestones and clays are not disturbed. We will see in the sequel that a similar later disturbance has taken place still further north in the vicinity of Denver.

Whatever alterations of level took place in the great lapse of time between these epochs were of the nature of continental elevations and subsidences, extending over large areas, and unmarked by any relative changes in the smaller parts of the regions involved.

§ 9. TRINIDAD TO DENVER.

Leaving Trinidad, October 18th, after mid-day, I observed the high terrace of sandstone described in § 4 enveloping the base of the mountain chain, as long as daylight permitted me to distinguish its outline. I learned afterwards from Dr. Steck, that coal beds have been seen in this northern extension of the formation which bears the coal of the Raton and Vermejo. A bed of similar coal is worked at Cañon City, in the hills south of the Arkansas, and, as I have mentioned in the preceding pages, supplies the blacksmith's forge at Fort Lyon.

From Trinidad to Denver the stage road passes over a country like that near the Purgatoire, covered with excellent grass. The streams, somewhat deficient in number and size south of the Arkansas, become more numerous and less variable north of that stream.

There is, therefore, a broad belt extending along the base of the mountains, admirably suited for either pasture or agriculture. Geologically, the surface is middle cretaceous south of the Arkansas, becoming upper cretaceous, with Ammonites and Baculites, north of Pueblo.

Near Colorado City there is a magnificent exposure of Trias and cretaceous beds, turned vertically; the softer strata have been removed by erosion, leaving the harder strata as immense walls worn into masses of singular beauty. The space between the eastern wall and the base of the metamorphic hills of the Rocky mountains is called the Garden of the Gods, and is famed for its peculiar yet beautiful scenery.

Near Colorado City, the Trias contains, as in the Purgatoire cañon, beds of gypsum and alum.

Coal is said to occur on the plains, east of Colorado City. No explorations have been made to determine its value.

The divide between the Arkansas and the South Platte is a high range of pale sandstone, capped in some places with conglomerate of a darker color and firmer texture. Along Monument creek, the atmospheric erosion of the frost and the rain, and especially of the wind, has worn the soft sandstone into pillars of most fantastic form. Rude giant statues with round heads, stare at the traveller from among the groves of evergreen cedar: monuments, carved by the many fingered hands of nature, stand in picturesque groups, partially surrounded with trees of dense foliage, and make inviting places of repose for the future lords of the fields and mines of Colorado.

Fossil woods of coniferous genera, sometimes opalized and of great beauty, occur near the summit of the divide.

The trees of the lower hills are cedar: pines of large size are abundant on the higher parts, and the top of the divide is a broad undulating surface, well watered and covered with luxuriant grass. Many farms have been established under good cultivation, and steam saw-mills in active operation, supply the lumber for Denver, whence it is carried in wagons as far as Shyenue, and even to Fort Wallace.

We arrived at Denver on the night of the 19th October. The next day a storm of rain and snow commenced, which delayed my visits to the coal mines until the 24th.

§ 10. COAL MINES OF DENVER.

The only important beds of coal which have been successfully worked near Denver, are (1), Murphy's, on Ralston creek, twelve miles from the city: (2), Marshall's on South Boulder creek, twenty-three miles, and (3), the Austin bed, on Coal creek, somewhat more distant.

Murphy's is a vertical bed running north and south, contained in the yellow sandstone, which here forms the easternmost of the abrupt rocky ridges called *hogbacks*. On the plateau above the mine, the edges of the upturned strata are concealed by a thick deposit of drift, but further north the sandstone is seen projecting

above the drift; the coal however has not been traced to that point.

Openings have been made on both sides of Ralston creek; the coal is uniform in quality and thickness, sixteen feet, free from slates. It is limited on the west by a bed of fire-clay, suitable for pottery and fire bricks, four feet thick, and on the east by a similar bed eight to ten feet thick; beyond these, in each direction is the yellow sandstone.

I did not succeed in obtaining any fossils at this mine, but observed in the coal evident traces of trunks of trees of exogenous growth.

Southwest from Murphy's about two miles distant, is a lime kiln in which lime of an excellent quality is burned from rocks of the Trias, or marl series, brought from the base of a hogback near the foot of the mountain: the ridge next east of the lime-bearing one is composed of lower cretaceous sandstone, hard in texture and gray in color; the strata run north and south, and dip about 70° to the east. Proceeding west from this ridge the following strata are met:

1. Red clays or marls.
2. Grayish-white limestone.
3. Thin bed of banded sandstone.
4. Wide bed of white limestone containing small cavities, lined with crystals of calcite.

The coal of the Murphy bed is sold at the mouth of the mine for \$4 per ton, and is extensively used for fuel in Denver. It is light, burns freely with voluminous flame, like all the coals of newer periods, leaving a small quantity, (4 per cent.) of yellow ash.

Beds of limonite or bog iron ore are found in the vicinity.

The Marshall bed is nearly horizontal, being inclined only 8° towards the east: the cleavage is vertical, bearing east and west. It exhibits eleven feet of solid coal, and is opened to a depth of nearly two hundred feet; it supplies a large portion of the fuel used in Denver. The quality is about the same as that of Murphy's bed, but the ash is less colored; it is similarly enclosed by thick beds of fire-clay.

Mr. Marshall, the highly intelligent superintendent of the mine, told me that the bed mined is the lowest which he has seen. Above it are ten others, varying in thickness, the thinnest being five and one-half feet, while the ninth from the lowest is of the

same thickness—eleven feet. These beds are separated by strata of from twenty-five to sixty feet of sandstone and clays.*

Large quantities of limonite are found within a few hundred yards, and have been worked to advantage in a small furnace, built on the same property. The iron was reduced by charcoal, and is of excellent quality, very soft and very pure.

I found in the beds of clay just below the coal, large numbers of impressions of leaves, unfortunately not very well preserved. Mr. Lesquereux, to whom I submitted them for examination, writes concerning them, as follows:

No. 1. *Acer*, allied to *A strictum* Göppert.

No. 2. A small fruit, apparently the upper part of the seed of a maple.

* The following section of the beds containing the coal at Marshall's is copied from a short paper by Dr. Hayden, "On the the Lignite Deposits of the West," which is published in Silliman's Journal, for March, 1868, and appeared while the foregoing pages were passing through the press:

45. Sandstone, gray and rather coarse-grained.	22. Drab clay, 5 feet.
44. Drab clay.	21. Sandstone, 20 feet.
43. Lignite.	20. Drab clay, 3 feet.
42. Drab clay.	19. Lignite, 7 feet.
41. Lignite.	18. Drab clay, 3 feet.
40. Drab clay.	17. Sandstone, 40 feet
39. Sandstone.	16. Drab clay. 3 feet.
38. Drab clay.	15. Lignite, 5 feet.
37. Lignite.	14. Drab clay.
36. Drab clay.	13. Sandstone.
35. Sandstone.	12. Drab clay.
34. Drab clay, 10-12 feet	11. Lignite.
33. Sandstone	10. Drab clay.
32. Drab clay	9. Sandstone.
31. Lignite.	8. Drab clay.
30. Drab clay.	7. Lignite, 5 feet.
29. Sandstone.	6. Drab clay.
28. Drab clay, passing up into sand, 3 feet.	5. Gray and yellowish gray sandstone.
27. Lignite, 5 feet	4. Drab clay, 3 feet.
26. Drab clay, 5 feet.	3. Lignite, 11-13 feet.
25. Sandstone, 14 feet.	2. Drab clay, 4 feet.
24. Drab clay, 3 feet.	1. Fine yellowish grit, indurated.
23. Lignite, 7½ feet.	

No. 3. Several fragments of leaves of a *Juglans*, allied to *J. acuminata* of the European tertiary.

No. 4. A leaf of a *Cornus*, closely related to *C. Studeri*, Heer.

No. 5. Two fragments of leaves of *Banksia Deikiana*, Heer.

The pieces of limonite collected contain fragments of leaves, mostly indeterminate, but in Mr. Lesquereux's opinion, rather of cretaceous than tertiary age.*

Proceeding westward from Marshall's towards the mountains, the following strata are exposed, becoming more and more highly inclined: the thickness is given as estimated by Mr. Marshall:

1. Limestone, containing a gigantic species of *Inoceramus*, figured but not described in Fremont's Report, about 400 feet. (Middle cretaceous.)

2. Sandstone, hard and white, used as hearthstones at the furnace. (Lower cretaceous, probably 2000 feet.)

3. Red sandstone and marls, fine-grained. (Trias about 1000 feet.)

4. Brown sandstone, coarse-grained. (Palæozoic, about 2500 feet.)

5. Metamorphic vertical strata of the mountains; gray and micaceous or hornblendic schists.

Between the white sandstone, (2) and the trias, (3) is a bed of magnesian limestone, ten feet, and reddish-white sandstone, forty feet, which may perhaps be Jurassic, as well defined beds of that period, with characteristic fossils are known by the explorations of Dr. Hayden, to occur further north.

My time was so limited that I was unable to visit the exposures of strata, but from subsequent observation near Golden City, I have no doubt that the sequence, as stated by Mr. Marshall, is accurate.

* I have given a very brief abstract of my correspondence with Mr. Lesquereux, on the subject of these, as of the other fossil plants collected during the journey. They will be described at length in a memoir now being prepared by Mr. Lesquereux, for publication in the Report of the Geological Survey of Nebraska, by my learned friend Dr. F. V. Hayden, now in charge of that survey. I will merely add here that the investigations of the fossil plants, while they may seem to indicate the Marshall bed to be very old (eocene) tertiary, show conclusively that the basin is more ancient than the coal deposits further north, which make part of the Great Lignite formation of Dr. Hayden, and therefore confirm by their evidence, the general dynamic opinions expressed in the present report.

I did not visit the Austin bed, but procured specimens from it at Burlington, where it is used for fuel. It has a yellow ash, and contains more sulphur than the coal of Marshall or Murphy.

Near Golden City a bed of coal is contained in the large beds of potter's clay, but according to my observation is of small extent and little value as compared with those described above. The clay is used both for pottery and fire-brick, and is altogether similar to that near the other coal beds already mentioned. The upheaving force has been so great that the beds are more than vertical, being tilted over at the upper part, so as to dip towards the mountains at an angle of probably 80° .

East of Golden City is a plateau nearly six hundred feet high, composed of horizontal sandy and clayey strata, containing badly preserved vegetable remains; it is capped by a thick sheet of basalt, which has been poured out from craters, the remnants of which exist on the grassy plain of the mesa as elliptical ponds. Around the base of the mesa, terraces of drift are seen, forming low hills, becoming less coarse in material as they approach the valley of the South Platte.

I observed in the valleys between Golden City and the mouth of the cañon called Golden Gate, some remains of crescentic ridges of drift, apparently the terminal moraines of small glaciers.

The strata west of Golden City are vertical, or nearly so, and are seen in the following order:

1st Hogback; yellow and variegated sandstone, containing the beds of pipe-clay and lignite and a bed of limonite.

Valley containing clay.

2d Hogback; clays and sandstone, (cretaceous.)

3d Hogback; limestone and soft white sandstone, succeeded by dark red sandstone and conglomerate (trias and palæozoic).

Mountain composed of stratified highly metamorphic rock, mostly gneissoid, with dikes and veins of red granite and quartz.

South of Golden City the trias, as usual, contains a gypsum bed.

Dr. Hayden has kindly communicated to me a copy of a section made at Golden City by Mr. E. L. Berthoud, in which the horizontal tertiary strata composing the mesa capped with volcanic rock, are given in detail. It will be published in connection with his report on the Geology of Nebraska.

These brief notes are only introduced here in order that the age the strata, entangled in the mountain structure, may be contrasted

with the much more simple composition of the chains seen further south and west.

In company with General John Pierce, formerly Surveyor-General of Colorado, I visited a place sometimes worked for coal, fifteen miles above Denver, near the Platte cañon. So much time was consumed in finding the place in consequence of changes in the river bed, produced by floods, that no satisfactory examination was made. I saw merely the including beds of clay, both of which, the upper and lower, have furnished to Gen. Pierce specimens of *Ammonites* and *Baculites*, indicating them, therefore, to be upper cretaceous. I learned from him that the bed of coal is four and one-half feet thick, and the quality less good than that obtained from the beds above mentioned, being similar to that of the Golden City bed. The dip, he informed me, is about 45° westwardly.

On the 25th of October I examined a bed of carbonaceous clay, on Coal creek, sixteen miles *east* of Denver.* It and similar beds in the neighborhood have been opened at various times, but the excavations have now caved in. I learned from gentlemen who had been engaged in the enterprize, that no useful coal was obtained. I collected some surface specimens which were dull, earthy and very fragile. The bed is about four feet thick, very impure, and dips slightly to the south and east. Below, the strata are clayey; above they are more sandy. I could find no fossils.

Many localities of coal or lignite are known east of Denver, but few have been sufficiently explored to enable an opinion to be expressed regarding the quality of the fuel. In no instance, however, where excavations have been made, has coal been obtained, at all comparable with that from the beds west of Denver: and I am disposed to believe that they are mostly beds of carbonaceous clay of cretaceous age, and will be found of little value. I would recommend a careful and economical exploration of some of the largest, which are said to be situated on the Big Sandy, a tributary of the Arkansas.

I learned from Gen. Pierce that on Cherry Fork of the Republican river, bones of large mammalia are found: he described to me a fragment which had been in his possession, which must have been a portion of the jaw of *Titanotherium* or the large *Rhinoceros*;

* This Coal creek must be carefully distinguished from the stream of the same name *north* of Denver, upon which the Austin bed is situated.

it is now, as he informed me, in the collection of the Smithsonian Institute.

With these remarks I terminate the notes of my reconnsissance. The remainder of the journey was over ground carefully investigated by Dr. Hayden, the pioneer and most successful explorer of the geology of the Missouri basin. Full accounts of his recent labors may be expected in the forthcoming report of the Geological Survey of Nebraska.

PART II.

RESOURCES OF THE COUNTRY ADJACENT TO THE LINE SURVEYED.

Believing that the pastoral, agricultural and manufacturing resources of every portion of our country are of more permanent national importance, both physically and morally, than the results of mining enterprises, however valuable the latter may appear, I shall give precedence in this part of my report to the characters of the regions traversed that relate to the former class of subjects.

The observations upon which the following remarks are based have been detailed in the first part of the report, and this second part is merely a condensation of the results, for the benefit of persons who may be interested in special matters connected with the future development of the interior of the continent.

§ 1. AGRICULTURAL RESOURCES.

The region between the Smoky Hill river and the Arkansas is useless for agricultural purposes, on account of the want of water, and can be used for grazing only by such domestic animals as do not require permanent places for quenching their thirst.

On reaching the Arkansas a wide valley of alluvial deposit is found; wherever irrigated, these bottom lands yield abundant crops, and the fall of the river, about eight feet per mile, is favorable for that method of cultivation.

The rain-fall in this part of the valley of the Arkansas (*vide* p. 13) is not sufficient to permit the making of permanent reservoirs for irrigating the elevated plains, which are covered with a scanty growth of buffalo grass.

Along the Purgatoire an abundant supply of water can be obtained by irrigating lands which lie in the river valley; the uplands are clothed with a good growth of grass, suitable for pas-

ture during the whole year; while the occurrence of water in cañons but a few miles distant from each other fits this region for grazing purposes. Reference to the topographical maps of the survey, when published, obviates the necessity of more extended comment upon this portion of the route.

The system of the Raton also offers much land suitable for pasture and agriculture. In the mountain valleys the climate is adapted to the cultivation of all garden products, including potatoes, which, as observed in the first part of the report, do not thrive in New Mexico.

South of the Raton the rain-fall became more abundant, and the streams more numerous, until about Fort Union, the only locality in which the experiment has been tried, artificial reservoirs for irrigation are readily constructed. The soil, as everywhere else on the route, yields abundantly, when irrigated. The uplands, as in the valley of the Purgatoire, are covered with good grass suitable for pasture.

From Vegas to the Pecos the country is well adapted for cultivation. South of the river the route follows cañons of little value, except for the grass and wood which they contain, until ascending the plateau at the head of Cañon Blanco, an undulating surface is again found, destitute of trees, it is true, but covered with excellent grass, and like the plains near Fort Union, adapted to the construction of reservoirs for irrigation.

Near the mountain chains adjacent to the Rio Grande the valleys become abrupt and narrower, and only small tracts can be irrigated.

The valley of the Rio Grande presents a belt of land from three to ten miles in width, which by a well-contrived system of irrigation will produce most abundant crops. For vineyards this valley is particularly applicable. The grapes, all of which belong to the European species, are superior to any of our own hot-house varieties, and although treated in a rude manner, altogether unworthy of so meritorious a fruit, they develop a wine comparable with the middle grades of Sauterne.

Fruits of the temperate zone, cereals and ordinary garden vegetables, except potatoes, are easily raised in the irrigated parts of the valley. Cotton is also grown to a small extent south of the Rio Puerco.

It is, therefore, apparent that from the Arkansas river to Fort

Craig, the agricultural resources of the country are not only ample for the supply of a large population, but that one of the products (wine) may be made a source of revenue to the road, beyond the demands of local traffic.

§ 2. MINERAL RESOURCES.

In proportion to their importance as connected with a railway enterprise, I will group the minerals observed near the route under four heads: *a*, coal; *b*, iron; *c*, building and other stones; *d*, metallic veins.

(a) Coal.

The coal beds of the region from Raton pass to near Maxwell's are extensive, thick, easily mined, and practically inexhaustible.

Those of the Rio Grande valley are widely diffused, not connected together in one system of undisturbed beds like those of the Raton, but somewhat inclined, and manifesting themselves at many places, each of which must be specially examined in order to determine its extent and value.

The anthracite near the Placer mountain, the coal of Tijeras and the beds west of Don Pedro are known to be of good quality; the first and third are capable of being worked for many years; of the extent of the second, but little is ascertained.

The supply contained in the beds visited, and in others, mentioned in the first part, some of which must be equally good, is sufficient for all demands for many years.

I have submitted specimens of some of the coals collected on the survey to Professor George J. Brush, of New Haven, from whom I have received the following report:

Examination of coal received from Dr. John L. Le Conte, made in the Laboratory of the Sheffield School of Yale College.

No. 1. "Coal from Vermejo river, south of Raton mountain."

This coal was dull on the exposed surface, but had a bright lustre on the fresh fracture. No pyrites was detected by the eye, although traces of oxide of iron were observed in some of the crevices. Specific gravity, 1.36, making the cubic foot to weigh about eighty-four and three-fourths pounds, averd. Analysis:

Loss at 110° C., (<i>water</i> ,)	3.27
Volatile matter, expelled above 110° C.,	23.73
Fixed carbon, (by loss)	59.72
Ash,	13.28 — 100.00

This coal does not give a coherent coke. Its ash has a brownish gray color. When heated with oxide of lead, according to Berthiers's method for determining calorific power, it was found that one part of coal would reduce 22·8 parts of lead, while pure carbon reduces 34 parts.

No. 2 "Anthracite, twenty miles southwest of Santa Fe, in San Lazaro hill of Placer mountain."

This coal is a pure looking anthracite, and analysis gave :

Water,	.	.	.	.	.	2·90
Volatile matter,	.	.	.	.	.	3·18
Fixed carbon,	.	.	.	.	.	88·91
Ash,	.	.	.	.	.	5·21 — 100·00

Specific gravity 1·49, weighing about $93\frac{1}{4}$ pounds per cubic foot. It was found that 1 part would reduce 30·89 parts of lead from the oxide, showing it to have a very high calorific power. The ash was of a light brownish gray color.

No. 3. "From Murphy's, near Denver."

This coal had a dull, almost waxy lustre, even on fresh fracture. Specific gravity 1·39, making the weight per cubic foot, about 87 pounds. Analysis :

Water,	.	.	.	.	.	11·70
Volatile matter,	.	.	.	.	.	29·07
Fixed carbon,	.	.	.	.	.	55·31
Ash,	.	.	.	.	.	3·92 — 100·00

The color of the ash was ochre yellow. One part of the coal reduced but 20·49 parts of lead from the oxide, showing it to be the poorest in calorific power of the three specimens examined, as might be conjectured from the large amount of water this coal contains. The sample appeared free from pyrites, and gave the lowest ash (3·92) of any of the specimens examined, but it did not give a coherent coke.

The opinions of Mr. L. Lesquereux respecting the quality of the coals which accompanied the vegetable fossils examined by him, are mentioned with the narrative of observations at each locality.

In comparison with German brown coals of tertiary age, the analyses show a general superiority in the New Mexican varieties : the same is also true in comparison with those of the Pacific coast. For the purpose of making this apparent to the reader, I have con-

structed the following tables; the authority for the German coals being the books cited in the foot note,* and for those of the Pacific coast, the Geological survey of California, by Prof. J. D. Whitney, as quoted by Dr. William M. Gabb.†

Locality.	Fixed carbon.	Volatile material.	Water.	Ash.
1. New Mexico,				
Vermejo cañon,	59.72	23.73	3.27	13.28
Placer anthracite,	88.91	3.18	2.90	5.21
2. Colorado,				
Murphy's, near Denver,	55.31	29.07	11.70	3.92
Marshall's " "	59.20	26.00	12.00	2.80
Coal creek, ‡	57.70	19.30	20.00	2.00
3. Pacific coast,				
A. Cretaceous,				
Bellingham Bay, W. T.	45.69	33.26	8.39	12.66
Nanaimo, Vancouver's Island,	46.31	32.16	2.98	18.55
B. Tertiary,				
Coos Bay, Oregon,	41.98	32.59	20.09	5.34
Monte Diablo, California,	40.65	40.36	13.47	5.52
do.	46.84	33.89	14.69	4.68
do.	44.92	40.27	13.84	0.97
do.	44.55	37.38	14.13	3.94
do.	36.35	35.62	20.53	7.50

GERMAN TERTIARY COALS.

Variety.	Carbon.	Hydrogen.	Combined water.	Hygroscopic water.
Fibrous, (faserige,)	48	1	31	20
Earthy, (erdige,)	56	2	22	20
Laminated, (muschlige,)	60	3	17	20

The ash is neglected in the foreign analyses, but is stated to average from 5 to 10 per cent. When first mined, the German

* PLATTNER, Vorlesungen über allgemeine Hüttenkunde, ed TH. RICHTER, Band 1, Freiberg, 1860.

KERL, BRUNO; Handbuch der metallurgischen Hüttenkunde, 2d ed. Band 1, Theil 1, Freiberg, 1861, (Braunkohl, p. 275, *et seq.*)

† Reports upon the Mineral Resources of the United States, Washington, 1867.

‡ The analyses of the Marshall coal and that of Coal creek, were made by Dr. Torrey, and are copied from Dr. Hayden's paper in Silliman's Journal, for March, 1868.

brown coals contain frequently nearly 50 per cent. of hygroscopic water, which by drying is reduced to 20 or 25 per cent.

The absolute heat effects of the German coals are given as follows:

Variety.	Air-dried.	Kiln-dried.
Fibrous,	·50	·63
Earthy,	·62	·76
Laminated,	·70	·84

The data obtained by Prof. Brush by the reduction of oxide of lead, when placed in a decimal form, pure carbon being unity, are:

Vermejo cañon,	·67
Placer anthracite,	·91
Denver, (Murphy's)	·60

As regards the extension of the lignite beds west of the Rio Grande, our information is derived from the excellent Geological Report of Ives' Expedition to the Colorado, by Dr. J. S. Newberry, to which I have had occasion to refer in the preceding pages.

In travelling from the west to the east, coal was first observed by Dr. Newberry, at camp 92, which by reference to the map I find was a few miles south of the Moqui villages. The bed is described as impure, about twelve feet in thickness, and contains many impressions of ferns having a resemblance to foreign species of Jurassic date. Early cretaceous sandstone with dicotyledonous leaves overlies the bed, which is composed of alternate layers, as follows:

Bituminous shale,	6 inches.
Coal,	10 "
Clay,	3 "
Bituminous shale,	6 "
Coal,	12 "
Clay,	2 "
Bituminous shale,	11 "
Coal,	6 "
Clay,	3 "
Coal,	9 "
Bituminous shale,	18 "
Coal,	15 "
Clay,	2 "
Bituminous shale,	12 "
Coal,	15 "
Bituminous shale,	3 "

Regarding the extent of this bed Dr. N. observes: "Five miles north I found it occupying the same position, but thin; and in several localities further east, where the exposures included its place in the series, it was not to be found." Lignite beds of lower cretaceous age, as well as the Jurassic bed of camp 92, were seen by Dr. Newberry at the Moqui villages, but the thickness in detailed section is not given. Lignites are also mentioned from camp 92 to camp 100, near Fort Defiance. I learn by a letter from Dr. Newberry, that in a later expedition to the valley of the San Juan he found these same lignites of cretaceous age in many localities north of the surveyed route, and especially in the valley of the San Juan, where they become enormously thickened. The report of his explorations will be looked for with great interest, as giving full information regarding these deposits, which are destined to be of immense value in the future development of the country.

(b) *Iron.*

Deposits of iron ore fit for working, are found in the sandstones of the Vermejo, as described on p. 24 of the first part of the report. Veins of specular, titaniferous and magnetic ore, occur in the metamorphic rocks of the mountains; those near Vegas are mentioned on p. 29. Large quantities of magnetic iron are found near the Ortiz mine, and beds of an argillaceous variety occur near the anthracite of the Placer mountain, as mentioned on p. 39.

Should the coal be capable of use for smelting iron, the localities of the latter will be found ample for all possible demands.

I have received from Messrs. Williams and Moss, the following results of the examination of some iron ores collected on the journey.

- | | | |
|---|-------|-----------|
| 1. Magnetic iron ore, Las Vegas, metallic iron, | 20.43 | per cent. |
| 2. " " " Placer mountain " " | 65.27 | " " |
| 3. Carboniferous iron ore, Vermejo cañon, | 21.91 | " " |
| 4. Carbonate of iron, near anthracite of Placer mountain, | 36.49 | " " |

(c) *Building and other Stones.*

It is merely necessary under this head to refer to the first part of the report to substantiate the fact that building stones of hard and durable nature can be obtained wherever needed, the gray granites of the Carnuel cañon being, perhaps, the poorest

that were seen on the route. Limestone fit for burning in kilns is also within easy reach along almost the whole line. Gypsum is found wherever the variegated marl series below the lower cretaceous sandstone is exposed; north of the Raton it is seen in the deepest part of the cañon of the Purgatoire; south of Vegas the localities become very numerous. A thick bed of alum occurs in the cañon of the Purgatoire. A very beautiful brownish porphyry, with long slender crystals of orthoclase, occurred at camp 42, south of the Raton mountain. Near the Ortiz mine of the Placer mountain, I obtained specimens of a white and black sienite, fully equal in beauty to the Quincy granite of Massachusetts. The carboniferous limestone of the mountains near the Rio Grande is, in some localities, a very ornamental stone, compact and durable. The cretaceous and palæozoic sandstones are also well adapted for building.

(d) *Metallic Veins.*

Very valuable gold placers have been found within the past year about twenty-five miles west of Maxwell's, and there is every reason to believe that the auriferous rocks occur through the whole mountain chain east of Taos. The extensive and rich gold deposits and veins of the Placer mountains are described in the first part of this report. For more full information the reader is referred to a recent pamphlet* by the Hon. C. P. Clever, Delegate to Congress from New Mexico.

Silver ores are known from several localities, and some, as for instance the silver glance of the Sierra Madalena, are of great value; but in general no attempt has been made to distinguish the argentiferous galenas from those which contain no silver; the examination of those procured by me is not very satisfactory, though enough to show that valuable mines will be found.

Copper ore in large quantity is found west of Maxwell's, in the neighborhood of the gold washings; another good mine has been opened in Tejas. Several other localities are noticed in my report, but none have been developed sufficiently to determine their value.

In general terms it may be said that valuable mines may be

* New Mexico; her resources; her necessities for railroad communication with the Atlantic and Pacific States; her great future. By Charles P. Clever, Delegate from New Mexico. Washington, 1868.

expected in all parts of the Taos mountain, in the mountain chains east of the Rio Grande, and in the short chains near the river, on the west side.

The ores submitted to Messrs. Williams & Moss gave the following results:

1. Plumbiferous ore, Placer mountain, gold, \$16.04; silver, \$1.50 per ton of 2,000 pounds.
2. Yellowish tufa, new Placer mountain, (Candelaria mine), gold, \$738.86; silver, \$7.54 per ton.
3. Cellular brown oxide of iron, new Placer mountain, (mammoth lead), no gold or silver.
4. Ferruginous quartz, top of ridge of old Placer mountain, no gold or silver.
5. Decomposed porphyry, with ochrey clay, near Ortiz mine; gold, a trace; silver, \$8.50 per ton.
6. Plumbiferous ore in quartz, Greenback Hill, between Zandia and old Placer mountains, no gold or silver.
7. Calc spar with galena, Zandia mountain, no gold or silver.
8. Vein stone of quartz, with galena, copper and iron pyrites, near Tijeras, gold, a trace; silver, \$5.27 per ton.
9. Galena with quartz, near Cerrillos, twenty-two miles southwest of Santa Fe,* gold, a trace; silver, \$11.31 per ton.
10. Ore, fifteen miles west of Savanal, gold, \$78.41; silver, \$15.08 per ton.
11. Quartz with galena, fifteen miles west of Savanal, gold, a trace; silver, \$8.04 per ton.
12. Ores from Sierra de los Ladrones, no gold or silver.
13. Cañon de Agua, near Socorro, no gold or silver.
14. Limonite, with green and blue carbonates of copper, Hanover mine, no gold or silver.

Other fragments of rock from various localities, believed by the persons who gave them to me to contain valuable metals, were examined, but with negative results.

* Mr. R. E. Owen, in his report on the mines in New Mexico, mentions this mine, and states (p. 53) that the ore contains sulphurets of arsenic, antimony and bismuth.

PART III.

GEOLOGICAL STRUCTURE AND DEVELOPMENT.

Under this heading I desired to prepare a brief sketch of the geology of the route, specially with reference to dynamics, but the materials essential to a proper understanding of the resources of the country have taken up so much space, that I will reserve for another occasion the discussion of the subject, and conclude the report by a few propositions, the evidence in favor of which is contained in part I.

If I have succeeded in presenting to the reader a clear picture of the appearance of the strata as observed by me during the journey, he will have no difficulty in accepting the following outline of the main geological features of the country. For convenience of description I will commence at the Rio Grande, and proceed eastward.

The volcanic outflows of the Rio Grande are neglected in this part of the report as being local, and unimportant to the general conclusions.

East of the Rio Grande, the great mountain chain, of which the Zandia is the highest part, consists of gray micaceous gneiss, and red pyroxenic granites, over which lie in succession carboniferous limestone and dark brown sandstone, inclining conformably to the east.

At the base of this chain, and of the mass to the east of it, the latter consisting of the two Placer mountains and Monte Largo, the white sandstone is not altogether conformable with the brown sandstone which it overlies, nor is it entangled in the mountain slopes; further east, it, as well as the superjacent gypsiferous marls, (trias), are disturbed at Filley's summit, which is the southern extremity of the next axis of elevation.

Beyond this, to Tecalote creek, the white palæozoic sandstone,

which contains *Stigmaria* and *Calamites*, the gypsiferous marls and the lower cretaceous sandstone lie conformably, and nearly horizontally; these strata compose the elevated plain, which, by deep erosion, has been converted into a series of mesas or table lands.

Passing through the most eastern range of the mountains west of Vegas, all these rocks are seen to be disturbed, highly inclined or even vertical, proving thereby, that while the Zandia and neighboring chain have not materially altered in form since the end of the palæozoic epoch, the elevation of the Vegas mountains has taken place mostly between the lower and middle cretaceous ages.

At the base of these mountains, appeared for the first time in our progress eastwardly, the middle cretaceous limestone and clays, lying unconformably against the lower cretaceous sandstone.

Our route from Fort Lyon to Vegas was over nearly horizontal strata of lower and middle cretaceous; the latter generally forming the surface, except in the vicinity of the Purgatoire, where the lower cretaceous is slightly elevated and hardened. The large volcanic mass of the Raton mountain breaks through these rocks, but neither it nor the subsidiary cones and lava streams farther south have disturbed them greatly.

When I again had an opportunity of approaching the mountains north of the Arkansas, I found the surface of the plains consisting of upper cretaceous, of which we had seen none in our journey south of that river; and on the flanks of the mountains, all the strata were involved in the upheaval, except the mesa of tertiary near Golden City, which is horizontal and capped with volcanic rock. It is therefore evident that this, a more eastern range than that of Vegas, has been more recent in assuming its final form, just as the development of the chain of Vegas is more recent than that of Zandia.

The period of this elevation must be fixed at the close of the cretaceous, or, if Mr. Lesquereux is correct in believing the Marshall coal bed to be of eocene age, in the early tertiary.

Connected with each of these latter elevations there were extensive volcanic disturbances, those of the Raton system being perhaps, the largest on the continent: those of the Denver mountains are limited to the base of the foot hills, where volcanic caps have covered tertiary strata.

The entire absence of carboniferous limestone in the mountains east of the chain near the Rio Grande is a very remarkable fact;

the overlying palæozoic sandstones are however present, though yet recognized only by position and not by fossils.

I think from the facts above stated, that I am justified in drawing the following conclusions :

1st. That the development of the present structure and surface of the continent from the Rio Grande, eastward to Kansas, has been by a series of gradual and extended elevations from the south to the north, lifting large tracts of land above the surface of the ocean, and connecting the islands of the palæozoic age into a mass of land, gradually growing towards the north and east.

2d. That the greater part of this elevation in the south, took place at the end of the lower cretaceous, and was accompanied also with the upheaval of one or more mountain chains ; that similar phenomena occurred farther north, at the end of the cretaceous or early tertiary.

3d. That after the first and during the middle cretaceous, the continent was developed farther by the formation of a great peninsula, running eastward, contracting the inter-continental cretaceous ocean, and preparing it for the division into two gulfs, which was finally accomplished at the end of the middle cretaceous.

4th. As a result of this division of the inter-continental ocean, the faunæ of the two gulfs became quite different in the later cretaceous period ; so that but few of the fossils of that time are common to the Missouri basin, and the regions south of the Arkansas.

5th. During this gradual progress of the continent towards the east and north, circumstances favorable to the accumulation of beds of lignite occurred successively at different places, giving rise to independent basins : those of the Rio Grande belonging to the lower cretaceous : those of the Raton, (as shown by the *Inoceramus*,) to the middle cretaceous : those of the Denver region to the latest cretaceous, or oldest tertiary ; but being in either case older than those of the Missouri, or Great Lignite beds of Dr. Hayden, which are probably miocene, and which thus continue the sequence as far north as observations have been made.

As the last pages of this report were passing through the press I saw in the March number of the American Journal of Science and Arts, a brief memoir by Dr. F. V. Hayden, "on the Lignite Deposits of the West," in which he reiterates his opinion, expressed previously,* that all the useful beds of lignite west of the Mississippi, are of tertiary age.

* Proc. Am. Phil. Soc., x. 307.

This opinion receives a certain amount of support from the similarity and identity of the fossil plants collected in these lignite beds, as determined by Mr. Lesquereux, with the miocene flora of Europe. The complete list of species is appended to Dr. Hayden's memoir, and the descriptions will be published, with illustrations, in the Geological Report of Nebraska.

To the deductions thus made from the fossil flora, I would respectfully, but briefly, make the following objections:

1. That lignite beds west of the Rio Grande were found by Dr. Newberry, in supposed Jurassic strata, and in the superjacent lower cretaceous sandstone.

2. That the lignite beds of the Rio Grande valley, are in such close proximity to the marl gypsiferous series as to require their reference to our western early cretaceous, (No. 1, or Dakota group of Messrs. Meek and Hayden).

3. That the beds of the Raton are undoubtedly cretaceous, since both Mr. R. E. Owen and myself, have obtained *Inocerami* in the sandstone containing the coal.

4. That these beds are newer than No. 1, and, as I think, than No. 2 (lower middle cretaceous), because these latter are found very slightly disturbed on the flanks of the Raton, at a lower level: and also because, when in journeying southward No. 2 becomes the surface rock, these great lignite beds, with the containing terrace of sandstone, have disappeared.

5. That Mr. Berthoud, as quoted by Dr. Hayden,* in 1862, while on a scout east of Pike's Peak, sixty-five miles, found a bed of coal, almost identical with the Golden City bed, 9 feet thick, lying almost horizontal, with bluffs one a half miles north, containing fine specimens of belemnites.

6. That Gen. John Pierce, as mentioned on p. 52 of this report, obtained on each side of a coal bed, near the Platte cañon, Ammonites and Baculites; this coal, being like that mentioned by Mr. Berthoud, similar to the bed at Golden City.

7. In the absence of characteristic fossils, there is no reason to believe that the vertical bed of Murphy, and the nearly horizontal bed of Marshall, are of different age from that of Golden City, or the last named, different from that of Platte river, above Denver.

8. That there is no evidence of any such extensive disturbance during the tertiary, as would make the lower portions of that formation, vertical at Golden City and Murphy's, while leaving newer

* Proc. Am. Phil. Soc. x., 303

portions horizontal, as in the mesa capped with volcanic rock, near the first mentioned place.

9. That the comparison between the fossil plants of our interior western region, and miocene plants of Europe, is unsatisfactory for the following reasons :

a. The two regions had been separated by the utmost extent to which any portions of land on the globe can be separated, viz : by one continent, (now the eastern or Apalachian part of North America) and two oceans, (the intercontinental ocean, now obliterated, and the Atlantic) ; these oceans having been continuous from north to south, without circumpolar land connection, by which a synchronous similarity of organic beings would be rendered probable.

b. That the early, (No. 1), cretaceous flora of the western part of the intervening, (Apalachian) continent, as preserved on the Missouri and at Fort Harker, so nearly resembled that of the European tertiary, as to mislead some of the best of the European students of fossil plants, and to cause them and others, to accuse our most experienced observers of misinterpreting the age of the strata in question.

c. It being therefore the case, that the difference between the plants of our early cretaceous and those of the European middle tertiary, could be ascertained only after much discussion, and by the aid of the stratigraphy of the region, we have no right from a few resemblances in vegetables, to infer the synchronism, either of the western lignite beds with each other, or of any of them, with European eocene and miocene, except when supported by palæontological evidence derived from animal remains : and this will appear still more reasonable when it is mentioned that one of the species from Rock creek, a *Platanus*, probably of miocene age, is not distinguishable from our existing sycamore, *P. occidentalis* : and that a *Berchemia* from the Raton beds, while related to one from the European miocene is still more closely allied to the *B. volubilis* of the southern swamps.*

10. It would therefore appear plausible in the absence of more direct evidence, to believe that since the introduction of dicotyledons in large numbers in our early cretaceous, there has not been any very great change in the types of structure ; and that such changes, while following *in general plan* those introduced on the eastern continent, during these periods, have not been synchronous with them : just as in the animal kingdom we find Cam-

* Lesquereux, *apud* Hayden, Am. Journ. Sc., March, 1868, p. 207.

elidæ, Rhinocerotidæ and Solidpeda now living on the other continent, while our camels, rhinoceroses and horses, with all the allied genera have long been extinct; and among reptiles, the great development of the extinct dragons took place on the other continent, in the Jurassic and lowest cretaceous, while corresponding and closely allied forms lived here during a period recognized as synchronous with the European upper cretaceous.

Note on the Fossil Reptiles, near Fort Wallace.

Mr. E. D. Cope has kindly furnished me with the following communication upon the collection of fossil bones, made by Dr. Thos. H. Turner, U. S. A., referred to on p. 11, which was received at the Academy of Natural Sciences of Philadelphia, while the last pages of this report were passing through the press. The gratitude of men of Science, both here and elsewhere, is due to Dr. Turner for his labors in thus preserving from destruction these valuable relics, and for his liberality in placing them in a museum where they can be so thoroughly studied. In the progress of the road, many similar specimens may be found, and the great interest which attaches to them, should cause every exertion to be made, in order to collect them and place them in proper hands for investigation.

"One of the most interesting results of the expedition has been the recovery of some of the largest representatives of the Ancient Marine Fauna of the region traversed by the route. The collection recently received from Dr. Turner, contains remains of two species of Marine Saurians, the larger of some forty feet in length, the other not more than half as large. Both are allied to the Plesiosaurus, the smaller being provisionally referred to the immediate American representative of that genus. The larger approaches genera already known from cretaceous rocks of New Jersey and southern States, called by Leidy Discosaurus and Brimosaurus. A much larger portion of the Kansas Reptile than of these, has however, been discovered, and sufficient to indicate its distinction from them, and that it was one of the largest and most formidable of the group of Saurians to which it belongs.

General peculiarities of structure may be indicated as follows: it possesses a tail of great length, which was elevated, compressed and adapted for sculling the ponderous body through the water. The limbs appear to have been disproportionately small. The sternal and pelvic plate-like bones are of great extent, but of little thickness, and indicate large abdominal and thoracic cavities. The dorsal line was no doubt highly ridged or keeled, a fit structure for an aquatic creature. Of the head, unfortunately little is known, and the form of the neck has not yet been determined, as the details of structure are as yet concealed in the matrix.

This dragon was named from the singular plates which project from the under surface of many of the vertebræ, *Elasmosaurus platyurus* Cope.

The smaller saurian was represented by the end of the muzzle with the teeth, and perhaps a few vertebræ. It has received the name of *Discosaurus carinatus* Cope.

Some scales of a large Physoclyst or Ctenoid fish, were found in the same matrix, which are closely allied, if not identical, with those found by Dr. LeConte, in rocks near Fort Wallace, and whose age he has elsewhere pointed out. A second Ctenoid fish also left remains."

CATALOGUE OF ROCKS.

BY DR. F. A. GENTH.

No. 1. Tufa. *Plains near Arkansas; crossing from F. Wallace.* It consists of two parts of strata, the lower being a finely crystalline and granular brownish-white limestone, slightly ferruginous, and containing minute fragments of shells; the upper forms tufaceous and mamillary concretions of carbonate of lime, showing very little crystalline, but more of an earthy structure.

No. 2. Tufa. *Old Fort Lyon; sandstone with incrustations.* A fine-grained, ferruginous, and somewhat manganiferous sandstone with incrustations, similar in structure to No. 1, consisting of a lower crystalline and an upper stratum of mamillary carbonate of lime.

No. 3. Tufa. *September 9th; crossing Pecos above sandstone.* Fine-grained carbonate of lime, more or less mixed with, and covered by tufaceous and mamillary carbonate of lime.

No. 4. Tufa. *September 7th; Salazar's Ranch above sandstone.* Grayish-white, porous, somewhat crystalline carbonate of lime, the cavities filled with a more pulverulent variety, coated with a thin crust of white and more dense carbonate of lime. The granular portion contains magnesia.

No. 5. Tufa. *September 13th; Mesa of Cañon Blanco.* Carbonate of lime, containing a considerable quantity of magnesia (mixed with a little quartz-sand), in flat pieces of a grayish and brownish-white color.

No. 6. *Krönig's Ranch near Fort Union.* Brownish-white with earthy structure, consisting of carbonate of lime with only a small percentage of magnesia. It incloses, more or less uniformly mixed through the whole mass, small rounded grains of quartz-sand and fragments of a ferruginous sandstone.

No. 7. Tufa. *September 17th; camp at Aguajes.* Calcareous incrustations upon a rock of a grayish and brownish color, angular fracture and no lustre. This rock probably results from the decomposition of a basaltic rock, and consists of a hydrous silicate

of alumina, and ferric oxide without lime and magnesia, much like some impure varieties of bole. It contains 27.43 per cent. of water.

No. 8. *Trinchera Pass; Trap Dyke*. A dense grayish-black basalt, kryptocrystalline, but showing with a good glass particles of augite and magnetite, and numerous grains of olivine.

No. 9. *Trinchera Pass; Summit (cretaceous)*. A yellowish-white, fine-grained flat piece of sandstone, containing through the whole mass a minute quantity of carbonate of lime.

No. 10. *Raton Pass Cañon*. Trachyte (perhaps Sanidine T.) The feldspathic mineral is the principal constituent. Color, dark gray with black spots; contains some magnetite, also small grains of olivine, and probably pyroxene.

An analysis gave:

Silicic Acid,	=	50.05
Alumina,	=	16.04
Oxide of Iron,	=	12.51
Magnesia,	=	9.02
Lime,	=	9.42
Soda and Potash,	=	2.83
Water,	=	0.13

From some additional experiments it appears that the rock contains about:

12.5	per cent. of Olivine.
17.0	" Pyroxene or Amphibole.?
10.0	" Magnetite.
50.5	" a Feldspathic mineral,

which may be Sanidine, oligoclase or another.

As long as some of the constituents cannot be obtained in a pure state, and *their* composition ascertained, a doubt must remain how much of the different bases belongs to the different constituents of the rock.

The rock resembles much some of the varieties of Nepheline lava at Niedermendig, Eifel.

No. 11. *Trinchera Pass; summit*. Trachyte (perhaps Sanidine T.) In plates; the mass is principally formed of a white feldspathic mineral with a small quantity of magnetite and pyroxene, which give it a grayish cast. It contains a considerable quantity of olivine, which, however, especially where the rock is decomposed, forms brownish-red specks, disseminated through it. This olivine somewhat resembles the ferruginous variety "Hyalosiderite."

An analysis gave :

Silicic Acid,	.	.	.	.	.	=	49.35
Alumina,	.	.	.	.	.	=	8.87
Ferric Oxide (partly FeO),	.	.	.	.	.	=	20.18
Lime,	.	.	.	.	.	=	8.07
Magnesia,	.	.	.	.	.	=	6.05
Soda,	.	.	.	.	.	=	2.74
Potash,	.	.	.	.	.	=	1.46
Water,	.	.	.	.	.	=	3.15
							99.87

The water indicates the presence of a zeolitic mineral.

No. 12. *Trinchera Pass; hill near camp.* Porous and slightly decomposed basalt. Kryptocrystalline, but with small particles of olivine and magnetite; the pores are filled with sphærosiderite and calcite, and the whole mass more or less coated with pulverulent carbonate of lime.

Color of a fresh fracture between grayish and greenish-black.

No. 13. *Trinchera Pass; summit.* Identical with No. 11.

No. 14. *Trinchera Pass; hill one mile above camp.* A porous, spongy, and cavernous basaltic lava of a reddish-brown color and no lustre. It shows no crystalline structure; no mineral can be distinguished in the mass, except olivine in small grains. Some of the cavities are coated with white calcareous incrustations.

No. 15. *Trinchera Pass; opposite Dyke.* Identical with No. 12.

No. 16. *Trinchera Pass.* Porous basaltic lava? of a reddish-brownish gray color. The cavities are filled with calcite, sometimes forming druses filled with acute rhombohedra. The mass of the rock contains reddish-brown grains of olivine.

No. 17. *Trinchera Pass.* Resembles No. 14, but is more dense and has less cavities, which, however, are elongated, thus showing either the direction in which the gases have escaped, or the lava stream flowed. Color, reddish brown, dull; olivine is present in small quantities. A few of the cavities are filled with calcite.

No. 18. *Old Volcano south of Trinchera.* A piece of basaltic lava, which distinctly shows that it has been in a semifluid state, and flowed. Color, dull, reddish-brown; finely porous and scoriaeous. Minute quantities of olivine are observed in it, but no other minerals.

No. 19. *Las Vegas; middle Cretaceous limestone.* In plates of an ash-gray color, above and below, inclosed in a chalk-like layer. Massive, without apparent crystalline structure, which is only very slightly perceived when strongly magnified. Through

the whole mass are disseminated numerous exceedingly minute black (? carbonaceous) grains. Consists principally of carbonate of lime with magnesia, and a little oxide of iron. On dissolving leaves a considerable quantity of insoluble matter, principally silica with some alumina.

No. 20. *Camp 42. Porphyritic Orthoclase Diorite?* Consists of a greenish-gray matrix, in which, however, by a good magnifying glass, no difference in the constituents can be distinguished; imbedded in it are slender crystals of a reddish-white orthoclase of from one-half to three-quarters of an inch in length, and about one-sixteenth of an inch in diameter. This is a beautiful rock.

No. 21. *September 9th; crossing Pecos on hills above sandstone.* Flint of grayish-white color with some dendrites. Translucent on fresh fractures, but opaque where it is weathered; fracture splintery and subconchoidal.

No. 22. *Purgatoire; mound before reaching Black Hills, Metamorphic No. 2, cretaceous.* A flat piece of limestone, where weathered, of brownish ochre-yellow color. A fresh fracture shows it to be of a brownish-gray color. Shows the same minute black grains observed in No. 19. Principally carbonate of lime, with carbonates of iron and magnesia, but containing a considerable portion of insoluble silicate of alumina, sand, &c.

No. 23. *Purgatoire; mound after passing Black Hills, Metamorphic No. 2, cretaceous.* A yellowish-white ferruginous limestone. Disseminated through the mass are shining specks (cleavage planes) of minute particles of crystalline calcite. It resembles No. 22 in composition, but seems to be more ferruginous. The insoluble portion contains a considerable quantity of sand.

No. 24. *July 25th; Purgatoire; on plateau near Bear painting.* A piece of dark-gray striped obsidian.

No. 25. *Purgatoire; camp at Cañon near Black Hills.* A grayish-black compact basalt, containing a considerable quantity of olivine in fine grains; magnetite is so finely divided through the mass that it cannot be distinguished; small particles of the rock, however, are easily attracted by a magnet.

No. 26. *Purgatoire; Black Hills.* Also a basalt. The quantity of olivine in it appears to be smaller, that of the feldspathic constituent larger than in No. 25. Shows a somewhat more crystalline structure; with a good glass, particles of the feldspathic mineral and magnetite can be distinguished.

No. 27. *Trinchera Pass; hill one mile above Camp (baked calcareous clay).* A limestone, slightly ferruginous and magnesian, but containing, besides the carbonates, a considerable quantity of silicate of alumina and sand. Somewhat hydraulic.

No. 28. *Gate of Hot Springs, Las Vegas, near wall of cretaceous No. 1.* Brownish-gray fine-grained sandstone. It also contains the fine grains of (? carbonaceous) matter observed in the limestones, Nos. 19 and 22.

No. 29. *Ocate to Fort Union.* Trachyte (perhaps Sanidine T.) Kryptocrystalline. Principally feldspathic matrix, with minute specks of magnetite and grains of olivine, disseminated through the whole mass.

No. 30. *September 17th; camp at Aguajes.* Ash-colored, slightly magnesian limestone, finely crystalline. Gives off a bituminous odor when dissolved.

No. 31. *Raton Pass Cañon.* Dark-gray massive rock without apparent crystalline structure, resembling the dense varieties of true "trap." Thin splinters have a brownish color. Odor strongly aluminous, when breathed upon.

No. 32. *Vermejo Cañon.* A dense, slightly porous, partly decomposed, basaltic lava; the pores more or less filled with calcite and sphaerosiderite.

No. 33. *Cañon Carnuel; Zandia Mountain.* Gneiss. Composed of grayish, slightly opalescent quartz, brownish-black mica and white feldspar, contains minute traces of a deep grass-green mineral in quantities too small to ascertain its nature; also a brownish mineral, which is either garnet or zircon.

One one side of the piece the constituents are present in about equal quantities, on the other mica predominates to such an extent that it appears to pass into mica slate.

No. 34. *Cañon Carnuel.* Gneiss. The constituents much like those of No. 33, but on the whole of a finer grain. The feldspar sometimes in larger crystalline grains.

No. 35. *Cañon Carnuel.* A peculiar rock of the habitus of syenite, but not containing any hornblende. It consists of large crystalline masses of dark flesh-red orthoclase, with minute quantities of epidote, and of an almost black micaceous mineral, and very little quartz.

If the micaceous mineral is really mica, the rock is a variety of granite.

No. 36. *Cañon Carnuel.* Mica slate, or more properly a quartzite slate, with very small quantities of mica of a yellowish and brownish color.

No. 37. *Cañon Carnuel.* Hornblende slate. One of the dark-greenish varieties of amphibole of a finely crystalline structure. The fissures and cavities contain crystalline calcite.

No. 38. *Cañon Carnuel.* Mica slate. Color between silver-

gray and greenish-gray. The constituents are so fine that individual particles can hardly be distinguished by a good glass. Contains a small admixture of brownish-black specks disseminated through the mass, probably garnets.

No. 39. *Cañon Carnuel*. Dense dark-gray magnesian limestone; massive with conchoidal fracture, contains a very large percentage of insoluble silicate of alumina, also some carbonaceous matter.

No. 40. *Cañon Carnuel*. Identical with No. 33, but containing a little more of the crystalline brownish mineral, which is either garnet or zircon.

No. 41. *Cañon Carnuel*. Identical with No. 37.

No. 42. *Cañon Carnuel; pebbles from bed of stream*. Three pieces of different quality. 1st. Flint of a dark grayish-black color, shading off into a grayish white. 2d. Black obsidian, almost colorless on thin edges, gray in thicker pieces. 3d. A very porous and fragile pumice stone of a brownish-white color, contains some particles of sanidine.

No. 43. *Pebbles from cretaceous sandstone near Galisteo Creek*. Quartz and flint pebbles. One, which has a reddish-brown color, seems to be a fossil coral.

No. 44. *Sandstone under Porphyry; Placer Mountain*. Gray and brownish-gray fine-grained sandstone, containing very little mica.

No. 45. *September 17th; camp at Aguajes*. A ferruginous sandstone of a brownish-red color; contains fossil bivalves. The fossils contain crystalline carbonate of lime, with black carbonaceous matter inclosed.

No. 46. *Raton Pass Cañon*. Ash-gray, massive, dense limestone, with uneven, somewhat splintery fracture. Small spots and lines of crystalline limestone indicate that it is fossiliferous. Contains a very large percentage of insoluble matter, but only a small percentage of magnesia.

No. 47. *Las Vegas, three miles west of Hot Springs; highly magnetic*. Ferruginous mica slate, quartz and garnets predominating.

No. 48. *Porphyry above Anthracite; Placer Mountain*. A peculiar porphyritic rock; apparently feldspathic matrix, with small crystals of orthoclase (or another feldspar?) and hornblende. I could not distinguish with certainty either mica or quartz. Color grayish, spotted with white.

No. 49. *Baked clay; Placer Mountain near Ortiz mine*. Dark gray, slightly granular, on breathing upon it aluminous odor; con-

tains also a very little mica. Sulphuric acid decomposes it, and the solution contains sulphate of alumina. The residue is very siliceous.

No. 50. *Placer Mountain near mine.* Brownish-yellow and brownish-red; resembles some varieties of pitchstone from Meissen, but it is not so vitreous.

No. 51. *Dyke (very small) near Galisteo Creek road from Santa Fe to Placer Mountain.* Decomposed Basalt. Color, gray spotted with white. Contains considerable quantity of olivine, but only a little magnetite. Both the feldspathic constituent and the olivine are, in part, converted into hydrous silicates.

No. 52. *Sandstone above Anthracite; Placer Mountain.* A gray and blackish sandstone, in some parts ferruginous from intermixed limonite; has impressions of leaves and other vegetable matter.

No. 53. *Marl under Lava, La Vejada, between Algodones and Santa Fe.* Contains a very large quantity of fine grains of sand of a white, yellowish, and reddish color, cemented by grayish-yellowish white substance, containing considerable quantities of carbonate of lime, a little alumina and magnesia.

No. 54. *Zandia mountain near Tejeras.* A yellowish-gray sandstone, with a streak of galena running through it.

No. 55. *Strata near Ortiz mine; Placer Mountain.* ? Trachyte. Grayish-white, apparently feldspathic matrix with crystalline feldspar disseminated through it. The rock contains also minute black grains of magnetite, and particles of pyrites. It shows numerous brown spots, which may have resulted from the oxidation of the pyrites. It also contains a small percentage of carbonate of lime. It resembles also some varieties of porphyry.

No. 56. *Tufa upon Lava stream: La Vejada, between Algodones and Santa Fe.* Basaltic rock, coated with a crust of carbonate of lime. Much decomposed, and pores more or less filled with calcite.

When treated with very dilute chlorhydric acid, which dissolves the carbonate of lime, the whole mass appears to be made up of minute particles of a feldspar (or of a zeolite), a small portion of a pyroxenic constituent, very little magnetite, and grains of olivine.

No. 57. *Tejeras Copper mine, vein rock.* Grayish-white clay with dendrites and foliated pale flesh-colored barytes.

No. 58. *Epidote rock; Placer Mountain.* Rock consisting of granular quartz and epidote; on one side the epidote is crystallized. Contains also decomposed pyrites in cubical crystals.

No. 59. *Slates above Anthracite; Placer Mountain.* Striped aluminous slate, the layers of colors between grayish-white and

grayish-black. Contains silicic acid, silicate of alumina and carbonaceous matter, but no lime and magnesia.

No. 60. *Placer Mountain, near Ortiz mine.* The rock consists of hornblende and feldspar, the latter appears to be albite or oligoclase or perhaps anorthite, which can only be ascertained by an analysis. I have not been able to distinguish, with certainty, any quartz.

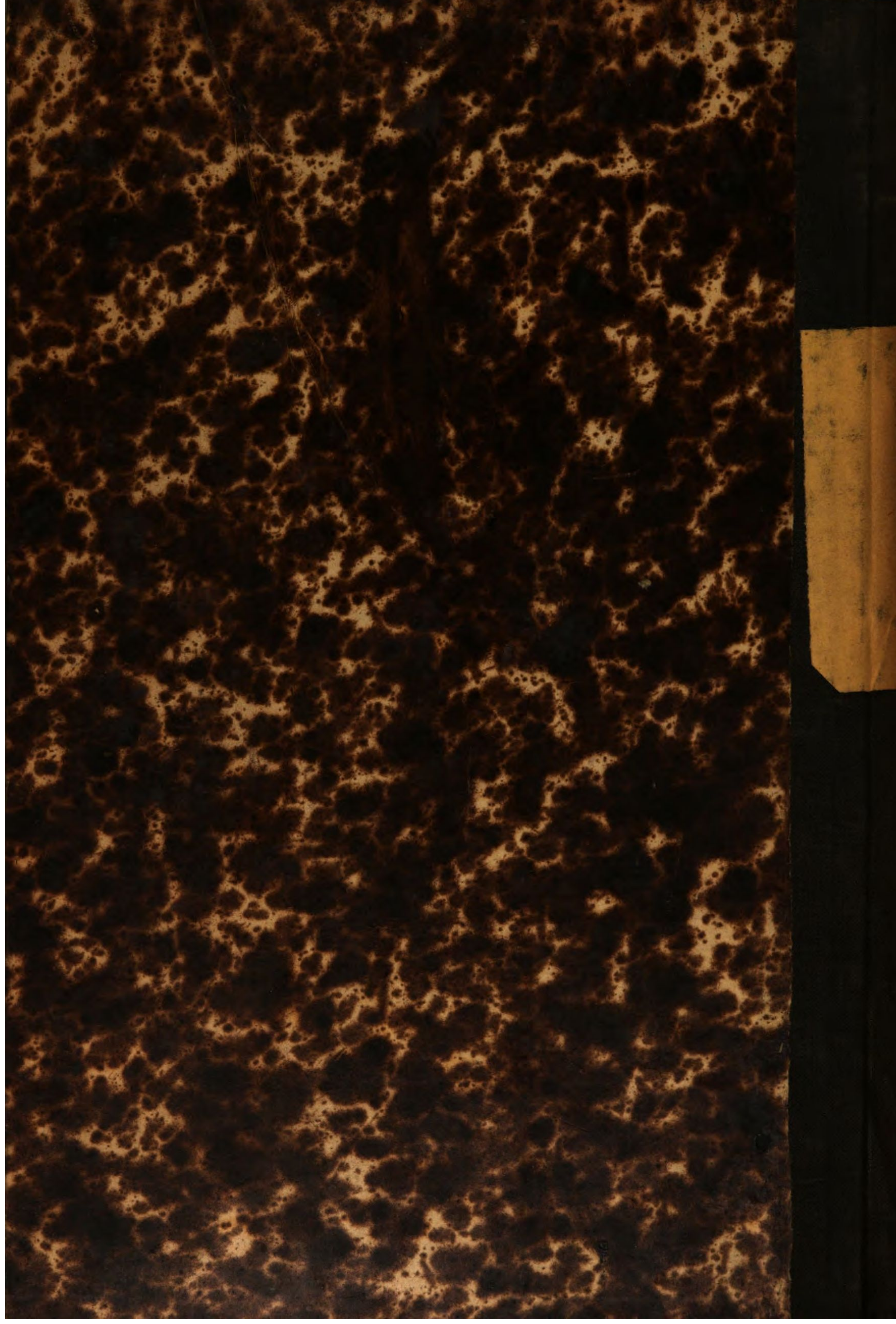
No. 61. *Top of old Placer Mountain. Col. Watts.* A very peculiar rock. The matrix consists of a grayish-white massive mineral of the appearance of the massive orthoclase or albite (so-called petrosilex). In this are found numerous globular masses, consisting of crystalline and granular quartz and epidote. The epidote frequently occupies the centres of the globules, but sometimes also accumulates at the edges.

No. 62. *Krönig's Ranch, near Fort Union.* Jaspery rock of a grayish-white and dark ash-gray color. Some portions coated, others thoroughly penetrated with a dark olive-green mineral, the nature of which could not be ascertained on account of the minute quantity. Fracture splintery. Incloses a vein made up of a mixture of limonite with fragments of jasper.

No. 63. *Gneissoid beds, nearly vertical: west of Golden City, Colorado Territory.* Gneiss. Some portions of a reddish, others of a darker color, according to the prevalence of either of the constituents. Principally composed of flesh-red orthoclase, with a very dark colored mica, contains very little quartz; also a few grains of a black mineral, and very small grains of garnet. Some portions are colored brown by limonite.

No. 64. *Red Granite Bed included in 63.* Coarse grained flesh-colored orthoclase predominating; quartz of a white and gray color in small quantity; brown mica in very minute quantities.

No. 65. *Volcanic Rock covering tertiary table lands east of Golden City, Colorado Territory.* Basaltic (?) lava (perhaps trachytic). Dark gray, massive, kryptocrystalline rock. The feldspathic constituent predominant, and in some places visible in cleavage fractures of one-eighth to one-quarter inch in diameter. In the weathered portion pyroxene can be distinguished. It contains a considerable quantity of magnetite, and a very minute admixture of olivine. The nature of the feldspar can only be determined by chemical analysis. It resembles some of the older Ætna lavas.



LeConte, John L.,

Notes on the Geology of the Survey for the Extension of the Union Pacific
Railway, E. D., from the Smoky Hill River, Kansas, to the Rio Grande

Philadelphia Febr. 1868

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